Bound
Periodical 1265824

Kansas City
Public Library

THE SCHOOL DISTRICT OF KANSAS CITY, MISSOURI.

This Volume is for

REFERENCE USE ONLY

PUBLIC LIBRARY
KANSAS CITY
MO

From the collection of the

Prelinger Library

San Francisco, California
2008

PUBLIC LIBRARY
KANSAS CITY
MO

PUBLIC LIBRARY
KANSAS CITY
MO.

Index to the
Bell Telephone Magazine

Volume XXIV, 1945

Information Department
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
New York 7, N. Y.

BELL TELEPHONE MAGAZINE

VOLUME XXIV, 1945

INDEX

A

	Issue	Page
Accounting Department:		
Films, use of, in training	Sp	25
		35
Increase in volume of work	Wi	309
Addicks, F. F.:	Wi	314
Adequate Earnings:		
Gherardi, Bancroft, quote on	Au	202
Quote from "The Bell Telephone System," by Arthur W. Page, on adequate earnings	Su	115
"Reasonable Earnings to Insure the Best Service" by Leroy A. Wilson—11 charts, 3 maps, 1 diagram	Au	137
American Telephone and Telegraph Company:		
Authorized Bell Laboratories to proceed with radar investigation	Wi	227
"Amphibious Operations"—4 photos	Su	96
Armantrout, Lawrence L.: Biographical sketch—port.	Sp	2
"Welcoming Bell System Veterans Back to Work"	Sp	20
"Army Airways Communications System: Nerve System of the AAF."—1 map, 3 diagrams, 16 photos	Su	76
"Army Air Forces Communications"—1 diagram, 4 photos	Su	74
"The Army Command and Administrative Network"—map	Su	68
The "Ash"—11 photos	Wi	273
Associated Companies:		
"The West Coast in the War" by George H. Jess—17 photos	Su	116
Aviation:		
"Guardians of the Skyways" by H. C. Lauderback	Au	188

B

	Issue	Page
Bell Laboratories:		
Projects will be developed from inventions to come	Sp	14
"Radar and Bell Laboratories" by Mervin J. Kelly—4 diagrams, 12 photos, 2 charts	Wi	221
Radar development—4 photos	Wi	262
Whippany plant—photo	Wi	227
Bell of Pennsylvania:		
"Dual Telephone Service Ends in Philadelphia" by Peter L. Schauble—6 photos	Wi	311
"The Bell System's First Order of Business" by Harold S. Osborne—12 photos	Wi	295

	Issue	Page
Bell Telephone Magazine:		
Index to Volume XXIV available	Wi	219
"Between Ships at Sea"—5 photos	Su	92
Biography:		
Armantrout, Lawrence L.—port.	Sp	2
Clark, T. Hunt—port.	Au	135
Jess, George H.—port.	Su	131
Kelly, Mervin J.—port.	Wi	218
Lack, Frederick R.—port.	Wi	218
Lauderback, H. C.—port.	Au	135
Mooney, Ralph E.—port.	Sp	3
Osborne, Harold S.—port.	Wi	219
Pilliod, James J.—port.	Su	131 132
Reynolds, Walter M.—port.	Au	134
Romnes, H. I.—port.	Au	135 187
Ryan, Harold L.—port.	Su	131 132
Schauble, Peter L.—port.	Wi	219 255
Shaw, John M.—port.	Sp	3
Sullivan, Mark R.—port.	Sp	2
Wilson, Leroy A.—port.	Au	134
"The Blackboard Comes to Life" by John M. Shaw—14 photos	Sp	25
Bown, Dr. Ralph:	Wi	231
Bush, Dr. Vannevar:	Wi	235
Business Offices:		
Custodians of System's good repute	Wi	307

C

	Issue	Page
C. and P. Company:		
"Outwitting a River on a Rampage" by Ralph E. Mooney	Sp	44
Camp Service:		
"The West Coast in the War" by George H. Jess	Su	126
Carrier Systems:		
"The Messages go Through in Many Ways," by H. I. Romnes—5 photos, 3 diagrams, map	Au	203
Charts:		
Distribution of telephones by class of service	Au	139
Financial trends, some wartime	Au	150
Growth in Bell System telephones and in U. S. population	Au	138
National income, net gain in Bell System telephones, and	Sp	15
Radar coverage extended beyond range of guns	Wi	235
Radiotelephone messages, number of	Au	142
Rates, average station-to-station day rates	Au	143
Ship telephone service	Au	142
Stock, A. T. & T. Co. (3)	Au	149
Stockholders, number and distribution of A. T. & T. Co.	Au	144

Issue Page
Telephones, net gain in Bell System . . . , and national income . . . Sp 15
Toll and long distance messages, number of . . . Au 140
Cincinnati Company:
"Outwitting a River on a Rampage" by Ralph E. Mooney . . Sp 46
Civil Aeronautics Administration:
"Guardians of the Skyways" by H. C. Lauderback—7 photos, 3 maps . . . Au 188
Clark, T. Hunt: Biography—port. . . . Au 135
"That First Call Home"—11 photos . . . Au 174
Coachella Valley Telephone Company:
"The West Coast in the War" by George H. Jess . . . Su 121
Coaxial Cables:
"Looking Ahead in the Bell System" by Mark R. Sullivan —photo . . . Sp 10
"The Messages go Through in Many Ways" by H. I. Romnes . . . Au 203
Progress of Bell System coaxial cable program—map . . . Au 152
Cockcroft, J. D.: . . . Wi 234
Colton, Maj. Gen. Roger B.:—port. . . . Wi 244
261
285

Commercial Department:
Films, use of, in training . . . Sp 26
35

Communications:
"Electrical Communications in World-wide Warfare" . . . Su 54
I. "On the Ground" by Harry C. Ingles—port—55 photos . . . Su 54
II. "In the Air" by Harold M. McClelland—port—24 photos . . . Su 73
III. "At Sea" by Joseph R. Redman—port—34 photos . . Su 85
"Eyes and Ears of a Carrier"—2 photos . . . Wi 269
Construction:
"The Bell System's First Order of Business" by Harold S. Osborne—12 photos . . . Wi 295
"Looking Ahead in the Bell System" by Mark R. Sullivan . . . Sp 15
"Reasonable Earnings to Insure the Best Service" by Leroy A. Wilson . . . Au 137
"Station Ashore"—6 photos . . . Su 88
"The West Coast in the War" by George H. Jess—17 photos . Su 116

D

Darwin, Sir Charles . . . Wi 234
Debarkation Service:
"That First Call Home" by T. Hunt Clark—11 photos . . . Au 174
Diagrams:
Aerial Communications Equipment . . . Su 84
"Army Air Forces Communications" . . . Su 74

	Issue	Page
Atlanta airways traffic control area illustrating the layout of the C.A.A. interphone network	Au	193
Carrier systems	Au	215
Direction finders for pilots	Su	80
Frequency variations for different types of transmission	Au	205
Ground-to-air contact with pilot	Su	79
"How War Consumes Telephone Wire"	Su	70
K-Carrier circuit between Cape Charles and Norfolk, Va.	Au	213
Landing Approach System	Su	81
Long distance connection established by operator dialing	Au	156
Manual toll operation	Su	102
Ohio step-by-step toll dialing network	Su	110
Operator Toll Dialing	Su	103
Radar antenna "scans" the target area	Wi	240
Radar development—2 diagrams	Wi	225
Radar helps control the fire of a ship's guns	Wi	237
Radio telephone service to motor vehicles	Sp	17
Radio telephony, urban mobile service	Au	154
Dial Systems:		
Long distance connection established by operator dialing—diagram	Au	156
"Looking Ahead in the Bell System" by Mark R. Sullivan—photo	Sp	12
"Operator Toll Dialing—A New Long Distance Method" by James J. Pilliod and Harold L. Ryan—2 diagrams, 3 maps, 3 photos	Su	101
Directories:		
Telephone service and	Wi	308
Dow, Commodore J. B.	Wi	225
"Dual Telephone Service Ends in Philadelphia" by Peter L. Schauble—6 photos	Wi	311

E

	Issue	Page
Eastman, Joseph B.: Quote on debt	Au	146
Editorial—N. Y. Times:		
Singing Wires	Sp	52
"Electrical Communications in World-wide Warfare":		
I. "On the Ground" by Harry C. Ingles—port—55 photos	Su	54
II. "In the Air" by Harold M. McClelland—port—24 photos	Su	73
III. "At Sea" by Joseph R. Redman—port—34 photos	Su	85
Electronics:		
"Electrical Communications in World-wide Warfare"	Su	54
I. "On the Ground" by Harry C. Ingles—port—55 photos	Su	54
II. "In the Air" by Harold M. McClelland—port—24 photos	Su	73
III. "At Sea" by Joseph R. Redman—port—34 photos	Su	85

Issue Page

Emergencies:
- "The Bell System's First Order of Business" by Harold S. Osborne—12 photos .... Wi 295
- "Outwitting A River on a Rampage" by Ralph E. Mooney—9 photos .... Sp 41

Employee Benefits:
- Stimulating interest in, through films .... Sp 27
- "Welcoming Bell System Veterans Back to Work" by Lawrence L. Armantrout .... Sp 21

Employee Morale:
- Making a humdrum job interesting through films .... Sp 27

Employees in Service:
- "Welcoming Bell System Veterans Back to Work" by Lawrence L. Armantrout .... Sp 20

Employment:
- "Looking Ahead in the Bell System" by Mark R. Sullivan ... Sp 16
- "Welcoming Bell System Veterans Back to Work" by Lawrence L. Armantrout .... Sp 20

Equipment:
- "The Bell System's First Order of Business" by Harold S. Osborne—12 photos .... Wi 295
- "Electrical Communications in World-wide Warfare" .... Su 54
  - I. "On the Ground" by Harry C. Ingles—port—55 photos .... Su 54
  - II. "In the Air" by Harold M. McClelland—port—24 photos .... Su 73
  - III. "At Sea" by Joseph R. Redman—port—34 photos. . Su 85
- "Looking Ahead in the Bell System" by Mark R. Sullivan—8 photos .... Sp 8, 12
- "Operator Toll Dialing—A New Long Distance Method" by James J. Pilliod and Harold L. Ryan—2 diagrams, 3 maps, 3 photos .... Su 101
- "Western Electric Tackles the Peace-time Emergency" by Walter M. Reynolds—13 photos .... Au 136, 158

"Eyes and Ears of a Carrier"—2 photos .... Wi 269

F

Federal Communications Commission:
- Keystone Telephone Company Merger and .... Wi 312
- Requested to provide for a general radio telephone service to motor vehicles on a common carrier basis, in their allocation of radio wave lengths .... Sp 14

Finance:
- "Looking Ahead in the Bell System" by Mark R. Sullivan ... Sp 18
- "Reasonable Earnings to Insure the Best Service" by Leroy A. Wilson .... Au 137
- Some wartime financial trends—chart .... Au 150

Issue Page

Floods:
  "Outwitting a River on a Rampage" by Ralph E. Mooney—9 photos .... Sp 41
"For Silent Ships"—1 map, 2 photos .... Su 90
Fowler, Sir Ralph .... Wi 234
Freehafer, Carl R.—port .... Wi 312, 319
"Fundamentals of Naval Communications"—1 map .... Su 86

G

Gherardi, Bancroft: Adequate earnings, quote on .... Au 202
Gifford, Walter S.: Earnings, quote on .... Au 157
  Letter from Major General Ingles praising Bell System "Communications Committee" .... Sp 19
  "Pledge to American Public" .... Wi 310
"Guardians of the Skyways" by H. C. Lauderback—7 photos, 3 maps .... Au 188

H

Hannenberg, Bill: .... Au 173
Held Applications:
  "The Bell System's First Order of Business" by Harold S. Osborne—12 photos .... Wi 295
  "Looking Ahead in the Bell System" by Mark R. Sullivan ... Sp 7
  "The West Coast in the War" by George H. Jess .... Su 129
"How War Consumes Telephone Wire"—Diagram, 1 photo .... Su 70
Hussey, Rear Admiral G. F., Jr.: .... Wi 250

I

Illinois Company:
  "Outwitting a River on a Rampage" by Ralph E. Mooney ... Sp 49
Indiana Company:
  "Outwitting a River on a Rampage" by Ralph E. Mooney ... Sp 49

Information Department:
  Role in production and procurement of training films .... Sp 40
Ingles, Harry C. (Maj. Gen.): "Electrical Communications in World-wide Warfare—I. On the Ground"—port—54 photos .... Su 54
  Letter to Walter S. Gifford praising Bell System "Communications Committee" .... Sp 19

J

Jess, George H.: Biographical sketch—port .... Su 131, 132
  "The West Coast in the War"—17 photos .... Su 116

Issue Page

K

Kelly, Mervin J.: Biography—port . . . . . Wi 218
  "Radar and Bell Laboratories"—4 diagrams, 12 photos, 2 charts . . . . . Wi 221
Keystone Telephone Company:
  "Dual Telephone Service Ends in Philadelphia" by Peter L. Schauble—6 photos . . . . . Wi 311
King, Admiral E. J.: . . . . . Wi 239

L

Lack, Frederick R.: Biography—port . . . . . Wi 218
  "Radar and Western Electric" . . . . . Wi 283
Lauderback, H. C.: Biography—port . . . . . Au 135
  "Guardians of the Skyways"—7 photos, 3 maps . . . . . Au 188
Levinger, David: . . . . . Wi 162, 165, 173
Long Distance:
  Long distance messages, number of—2 charts . . . . . Au 140, 141
  "Looking Ahead in the Bell System" by Mark R. Sullivan . . . Sp 10
  "The West Coast in the War" by George H. Jess—17 photos . Su 116
Long Distance—Operator Dialing:
  Development of toll line dialing by operators . . . . . Sp 12
  Long distance connection established by operator dialing—diagram . . . . . Au 156
  "Operator Toll Dialing—A New Long Distance Method" by James J. Pilliod and Harold L. Ryan—2 diagrams, 3 maps, 3 photos . . . . . Su 101
Long Distance—Subscriber Dialing:
  "Looking Ahead in the Bell System" by Mark R. Sullivan—photo . . . . . Sp 13
Long Lines Department:
  Floods, protective measures against . . . . . Sp 42
  Overseas switchboard, picture of . . . . . Sp 16
  "The West Coast in the War" by George H. Jess . . . . . Su 129
"Looking Ahead in the Bell System": by Mark R. Sullivan—10 photos, chart, diagram . . . . . Sp 5
Loomis, Dr. Alfred L.: . . . . . Wi 231

M

McClelland, Harold M. (Maj. Gen.): "Electrical Communications in World-wide Warfare—II. "In the Air"—port—24 photos, 5 diagrams, 2 maps . . . . . Su 73
"The Main Channels of Military Communication"—55 photos . . . . Su 55
Maps:
  Areas for the nation-wide numbering plan, U. S.—map . . . . . Su 105
  Bomber Command in contact with Air Force Headquarters . . Su 82

Issue Page
Cape Charles-Norfolk, Va. radio telephone circuit .... Au 213
Civil Aeronautics Administration interphone network .... Au 192, 193
Coaxial cables, progress of Bell System program .... Au 152
Florida, radar map of .... Wi 256
Naval Communications system, major point-to-point circuits of ...... Su 86
Navy Radio Broadcasting Stations .... Su 90
Ohio step-by-step toll dialing network .... Su 110
Radar map of Cape Cod area—photo .... Wi 223
Radio relay system—New York—Boston .... Au 153
Radio telephony, Bell System direct overseas circuits—present and planned ...... Au 155
Radioteletypewriter circuits .... Su 68
Routing a call from Gettysburg, Pa., to Fresno, Cal. .... Su 107
San Francisco to Saipan .... Su 76
Teletypewriter network of the Civil Aeronautic Administration ...... Au 194

Mergers:
"Dual Telephone Service Ends in Philadelphia" by Peter L. Schauble—6 photos ...... Wi 311

"Messages Go Through in Many Ways, The" by H. I. Romnes—5 photos, 3 diagrams, map ...... Au 203

Military Telephone Service:
"Electrical Communications in World-wide Warfare"
I. "On the Ground" by Harry C. Ingles—port—55 photos ...... Su 54
II. "In the Air" by Harold M. McClelland—port—24 photos ...... Su 73
III. "At Sea" by Joseph R. Redman—port—34 photos .. Su 85

Mobile Radio Telephone Service
See **Radio Telephony**

Mooney, Ralph E.: Biographical sketch—port .... Su 3
"Outwitting a River on a Rampage"—9 photos .... Sp 41

Motion Pictures:
"The Blackboard Comes to Life" by John M. Shaw—14 photos ...... Sp 25

Motion Pictures—Catalogues:
Nearly 200 films listed in Bell System catalogue—photo ..... Sp 27

N

National Defense Research Committee:
Radar development .... Wi 262
Radar program .... Wi 231

"Naval Air Transport Service"—5 photos .... Su 98

Naval Research Laboratory:
"Radar and Bell Laboratories" by Mervin J. Kelly—4 diagrams, 12 photos, 2 charts ...... Wi 221

"Navy Communications Center"—4 photos .... Su 100

Issue Page

New Jersey Telephone Company:
"Dual Telephone Service Ends in Philadelphia" by Peter L. Schauble—6 photos ..... Wi 311

O

Ohio Company:
"Outwitting a River on a Rampage" by Ralph E. Mooney ... Sp 45
Oliphant, M. L.: ..... Wi 235
"On Shipboard"—6 photos ..... Su 94
Operator Long Distance Dialing
See **Long Distance—Operator Dialing**
"Operator Toll Dialing—A New Long Distance Method" by James J. Pilliod and Harold L. Ryan—2 diagrams, 3 maps, 3 photos ..... Su 101
Operators:
"Operator Toll Dialing—A New Long Distance Method" by James J. Pilliod and Harold L. Ryan—2 diagrams, 3 maps, 3 photos ..... Su 101
Recruiting ..... Wi 309
"The West Coast in the War" by George H. Jess ..... Su 125
Osborne, Harold S.: "The Bell System's First Order of Business"—12 photos ..... Wi 295
Biography—port ..... Wi 219
"Outwitting a River on a Rampage" by Ralph E. Mooney—9 photos ..... Sp 41

P

Pacific Company:
"The West Coast in the War" by George H. Jess—17 photos. Su 116
Page, Arthur W.: Quote from "The Bell Telephone System" on technological improvement ..... Su 115
Quote from "What We Think About Held Orders" ..... Wi 298
299

Patton, George S. (General): ..... Su 119
120

Pilliod, James J.: Biographical sketch—port ..... Su 131
132

Pilliod, James J. and Ryan, Harold L.:
"Operator Toll Dialing—A New Long Distance Method" —3 maps, 2 diagrams, 3 photos ..... Su 101
Plant Department:
"The Bell System's First Order of Business" by Harold S. Osborne—12 photos ..... Wi 295
Films, use of, in training ..... Sp 25
26
37

Podzimek, Joe: ..... Au 171
172

Issue Page

Policies:
  Bell System policy .... Sp 24
Post-War Planning:
  "Looking Ahead in the Bell System" by Mark R. Sullivan—10 photos, chart, diagram .... Sp 5
  "Operator Toll Dialing—A New Long Distance Method" by James J. Pilliod and Harold L. Ryan—2 diagrams, 3 maps, 3 photos .... Su 101
Price, Ralph: .... Au 170

R

Radar:
  The "Ash"—11 photos .... Wi 273
  "Electrical Communications in World-wide Warfare—II. "In the Air" by Maj. Gen. Harold M. McClelland—2 maps, 5 diagrams, 25 photos .... Su 73
  R.D.R.—3 photos .... Wi 282
  Radar: A Story in Pictures—54 photos .... Wi 257
  "Radar and Bell Laboratories" by Mervin J. Kelly—4 diagrams, 12 photos, 2 charts .... Wi 221
  Radar—and the Engineer—2 photos .... Wi 271
  "Radar and Western Electric" by Frederick R. Lack .... Wi 283
  Radar at Sea—2 photos .... Wi 268
  Radar development—4 photos .... Wi 262
  Radar in the Air—3 photos .... Wi 267
  Radar—its test in battle—5 photos .... Wi 264
  Radar tooling—3 photos .... Wi 272
  Radar's inventors—2 photos .... Wi 261
  These women made radar—11 photos .... Wi 278
Radio:
  "Electrical Communications in World-wide Warfare"
    I. "On the Ground" by Harry C. Ingles—port—55 photos .... Su 54
    II. "In the Air" by Harold M. McClelland—port—24 photos .... Su 73
    III. "At Sea" by Joseph R. Redman—port—34 photos .. Su 85
  "The Messages go Through in Many Ways" by H. I. Romnes .... Au 203
Radio Relay System:
  "Looking Ahead in the Bell System" by Mark R. Sullivan ... Sp 11
  "The Messages go Through in Many Ways" by H. I. Romnes .... Au 215
  New York—Boston—map .... Au 153
Radio Telephony:
  Bell System direct overseas circuits—present and planned—map .... Au 155
  Cape Charles-Norfolk, Va. radio telephone circuit—diagram .. Au 213
  "Electrical Communications in World-wide Warfare" ...... Su 54
    I. "On the Ground" by Harry C. Ingles—port—55 photos .... Su 54

Issue Page

II. "In the Air" by Harold M. McClelland—port—24 photos .... Su 73

III. "At Sea" by Joseph R. Redman—port—34 photos .. Su 85

"Guardians of the Skyways" by H. C. Lauderback—7 photos, 3 maps .... Au 188

"Looking Ahead in the Bell System" by Mark R. Sullivan —diagram .... Sp 14
17

"The Messages go Through in Many Ways" by H. I. Romnes .... Au 203

Quote from a "Telephone Hour" radio broadcast on radio telephony .... Su 132

Radiotelephone messages, number of—chart .... Au 142

Urban mobile radiotelephone service—diagram .... Au 154

Rates—Telephone:

"Operator Toll Dialing—A New Long Distance Method" by James J. Pilliod and Harold L. Ryan—2 diagrams, 3 maps, 3 photos .... Su 101

Quote from "The Bell Telephone System" by Arthur W. Page on telephone rates .... Su 115

Rates—Telephone—Long Distance:

Average station-to-station day rates .... Au 143

"Reasonable Earnings to Insure the Best Service" by Leroy A. Wilson—11 charts, 3 maps, 1 diagram .... Au 137

Reconversion:

"Western Electric Tackles the Peace-time Emergency" by Walter M. Reynolds—13 photos .... Au 136
158

Western Electric turns to peace .... Wi 297

Redman, Joseph R. (Rear Admiral): "Electrical Communications in World-wide Warfare—III. "At Sea"—2 maps, 34 photos .... Su 85

Research:

"The Messages Go Through in Many Ways" by H. I. Romnes .... Au 203

Quote from "The Bell Telephone System" by Arthur W. Page on research .... Su 115

"Radar and Bell Laboratories" by Mervin J. Kelly—4 diagrams, 12 photos, 2 charts .... Wi 221

Radar development—4 photos .... Wi 262

Reynolds, Walter M.: Biography—port .... Au 134

"Western Electric Tackles the Peace-time Emergency"—13 photos .... Au 136
158

Romnes, H. I.: Biography—port .... Au 135
187

"The Messages Go Through in Many Ways"—5 photos, 3 diagrams, map .... Au 203

Root: J. W.: port .... Wi 315
319

Issue Page

Ruble, Capt. W. G.: Wi 225

Rural Service:
  "Looking Ahead in the Bell System" by Mark R. Sullivan—photo Sp 12

Rural Telephone Service:
  "Reasonable Earnings to Insure the Best Service" by Leroy A. Wilson Au 157

Ryan, Harold L.: Biographical sketch—port Su 131, 132
  "Operator Toll Dialing—A New Long Distance Method" by Harold L. Ryan and James J. Pilliod—3 maps, 2 diagrams, 3 photos Su 101

S

Schauble, Peter L.: Biography—port Wi 219
  "Dual Telephone Service Ends in Philadelphia"—6 photos Wi 311

Shaw, John M.: Biographical sketch—port Sp 3
  "The Blackboard Comes to Life"—14 photos Sp 25

Ship Telephone Service—Chart Au 142

"Singing Wires"—New York Times editorial Sp 52

Slide Films:
  "The Blackboard Comes to Life" by John M. Shaw—14 photos Sp 25

Southern Bell Company:
  "Outwitting a River on a Rampage" by Ralph E. Mooney Sp 47, 49

"Station Ashore"—6 photos Su 88

"Station War"—5 photos Su 72

Stock: 3 charts Au 148, 149

Stockholders:
  Number and distribution of—chart Au 144
  "Reasonable Earnings to Insure the Best Service" by Leroy A. Wilson Au 137

Subscriber Dialing
  See **Long Distance—Subscriber Dialing**

Sullivan, Mark R.: Biographical sketch—port Sp 2
  "Looking Ahead in the Bell System"—18 photos, chart, diagram Sp 5

Surveys:
  Keystone Telephone Company subscribers Wi 315

T

Taylor, Dr. A. H.: Wi 225
  Port Wi 261

Telephone Centers:
  "That First Call Home" by T. Hunt Clark—11 photos Au 174

Issue Page

Telephone Service:
"The Bell System's First Order of Business" by Harold S. Osborne—12 photos .... Wi 295
"Dual Telephone Service Ends in Philadelphia" by Peter L. Schauble—6 photos .... Wi 311
"The Messages Go Through in Many Ways" by H. I. Romnes .... Au 203
Quote from A. T. & T. Annual Report for 1945 .... Wi 310
"Reasonable Earnings to Insure the Best Service" by Leroy A. Wilson .... Au 137

Telephones:
"The Bell System's First Order of Business" by Harold S. Osborne—12 photos .... Wi 295
"Panic on the Telephone" .... Wi 294

Telephones—History:
"Operator Toll Dialing—A New Long Distance Method" by James J. Pilliod and Harold L. Ryan—2 diagrams, 3 maps, 3 photos .... Su 101
"Reasonable Earnings to Insure the Best Service" by Leroy A. Wilson .... Au 137

Telephones—Statistics:
Distribution of telephones by class of service .... Au 139
Growth in Bell System telephones and in U. S. population .. Au 138
"Reasonable Earnings to Insure the Best Service" by Leroy A. Wilson .... Au 137
Toll and long distance messages, number of .... Au 140

Telephotography:
"The Messages go Through in Many Ways" by H. I. Romnes .... Au 203

Teletypewriters:
"Electrical Communications in World-wide Warfare" .... Su 54
I. "On the Ground" by Harry C. Ingles—port—55 photos .... Su 54
II. "In the Air" by Harold M. McClelland—port—24 photos .... Su 73
III. "At Sea" by Joseph R. Redman—port—34 photos .. Su 85
"Guardians of the Skyways" by H. C. Lauderback .... Au 188
"The Messages go Through in Many Ways" by H. I. Romnes .... Au 203
"The West Coast in the War" by George H. Jess .... Su 125

Television:
"Looking Ahead in the Bell System" by Mark R. Sullivan .. Sp 11
"The Messages go Through in Many Ways" by H. I. Romnes .... Au 203

"That First Call Home" by Clark T. Hunt—11 photos .... Au 174

Timm, Bill: .... Au 166

Tizard, Sir Henry .... Wi 232

Toll Calls:
Number of toll and long distance messages—chart .... Au 140

Issue Page

Traffic Department:
  Films, use of, in training .... Sp 26
   38
  Telephone service and .... Wi 308
  "The West Coast in the War" by George H. Jess .... Su 116
Training:
  Bell Laboratories "School for War Training"—photo .... Wi 253
  "The Blackboard Comes to Life" by John M. Shaw—14 photos .... Sp 25
  Off-the-job class-room instruction for Western Electric employees .... Wi 299
  "Welcoming Bell System Veterans Back to Work" by Lawrence L. Armantrout .... Sp 22
   24
"Twentieth Air Force Communications"—1 map, 1 diagram, 4 photos .... Su 82

V

Veterans—World War II:
  "Welcoming Bell System Veterans Back to Work" by Lawrence L. Armantrout .... Ap 22
   24
Visual Aids:
  "The Blackboard Comes to Life" by John M. Shaw—14 photos .... Sp 25

W

Watson-Watt, Sir: .... Wi 261
"Welcoming Bell System Veterans Back to Work" by Lawrence L. Armantrout .... Sp 20
"The West Coast in the War" by George H. Jess—17 photos .... Su 116
Western Electric Company:
  "Radar and Bell Laboratories" by Mervin J. Kelly—4 diagrams, 12 photos, 2 charts .... Wi 221
  "Radar and Western Electric" by Frederick R. Lack .... Wi 283
  These women made radar—11 photos .... Wi 278
  "The West Coast in the War" by George H. Jess—17 photos. Su 116
  "Western Electric Tackles the Peace-time Emergency" by Walter M. Reynolds—13 photos .... Au 136
   158
"Western Electric Tackles the Peace-time Emergency" by Walter M. Reynolds—13 photos .... Au 136
   158
Wilson, Leroy A.: Biography—port .... Au 134
  "Reasonable Earnings to Insure the Best Service"—11 charts, 3 maps, 1 diagram .... Au 137
Women:
  "Radar and Western Electric" .... Wi 289
  These women made radar—11 photos .... Wi 278

Issue Page
World War II:
"Communications Committee," letter from Major General Ingles in praise of .... Sp 19
"Electrical Communications in World-wide Warfare" .... Su 54
I. "On the Ground" by Harry C. Ingles—port—55 photos .... Su 54
II. "In the Air" by Harold M. McClelland—port—24 photos .... Su 73
III. "At Sea" by Joseph R. Redman—port—34 photos .. Su 85
"Eyes and Ears of a Carrier"—2 photos .... Wi 269
Radar: A story in pictures—54 photos .... Wi 257
"Radar and Bell Laboratories" by Mervin J. Kelly—4 diagrams, 12 photos, 2 charts .... Wi 221
"Radar and Western Electric" by Frederick R. Lack .... Wi 283
"The West Coast in the War" by George H. Jess—17 photos. Su 116

ne XXIV ❧ Number One Spring 1945

[illegible]

Bell Telephone MAGAZINE

Kansas City, Mo.

Looking Ahead in the Bell System • Mark R. Sullivan

elcoming Bell System Veterans Back to Work • Lawrence L. Armantrout

The Blackboard Comes to Life • John M. Shaw

Outwitting a River on a Rampage • Ralph E. Mooney

rican Telephone & Telegraph Company · New York

Bell Telephone *Magazine*

Spring 1945

Looking Ahead in the Bell System, *Mark R. Sullivan,* 5

Welcoming Bell System Veterans Back to Work,
Lawrence L. Armantrout, 20

The Blackboard Comes to Life, *John M. Shaw,* 25

Outwitting a River on a Rampage, *Ralph E. Mooney,* 41

"The ideal and aim of the American Telephone and Telegraph Company and its Associated Companies is a telephone service for the nation, free, so far as humanly possible, from imperfections, errors, or delays, and enabling anyone anywhere to pick up a telephone and talk to anyone else anywhere else, clearly, quickly and at a reasonable cost."

A Medium of Suggestion & a Record of Progress

Published for the supervisory forces of the Bell System by the Information Department of
American Telephone and Telegraph Co., *195 Broadway, New York 7, N. Y.*
Walter S. Gifford, *President;* Robert H. Strahan, *Secretary;* Donald R. Belcher, *Treasurer*

Who's Who & What's What
in This Issue

LOOKING AHEAD—foresight—is a prime requisite of the telephone industry even in normal times, and a characteristic of the industry's leaders. It assumes redoubled importance now, in view of the problems and uncertainties which appear to loom large in the years immediately after victory. Into this period MARK R. SULLIVAN takes a long look; and what he sees ahead augurs well for increased and improved service to the public while presenting to the Bell System opportunities for great accomplishment. Joining the Pacific Telephone and Telegraph Company as a traffic clerk in 1912, Mr. Sullivan had become by 1928 general traffic manager of the company's Northern California-Nevada area. Six years later he was made vice president and general manager of that area, in 1938 his duties became company-wide when he was made chief of staff of the operating vice president's organization, and the following year he was elected vice president in charge of operations. In 1941 he left the Pacific Coast to become a vice president of the A. T. & T. Company, where he is head of the Department of Operation and Engineering. His previous contributions to this MAGAZINE include "The Organization of Large-scale Engineering Work," "The Bell System's Post-war Construction Program," and "The Impact of War on Long Distance Service."

MARK R. SULLIVAN

UNCERTAINTIES there may be as to what peace may bring; but there is no doubt about the cordial welcome which awaits Bell System employees returning from the war, the thought and care which have gone into the plans for re-establishing these 60,000 men and women happily and pro-

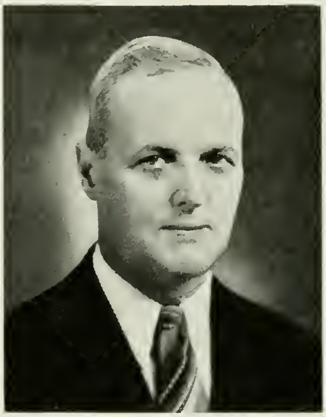
LAWRENCE L. ARMANTROUT

ductively in the organization, and the need for their contributions to the continuing growth of the business. LAWRENCE L. ARMANTROUT, who makes clear these matters in later pages, joined the A. T. & T. Company's Personnel Relations Department in 1943, coming to it from the Michigan Bell Telephone Company. In that company, he entered the Traffic Department in 1925, and held various assignments involving manual, dial, and toll operation until, in 1937, he was transferred to the company's Personnel Department. Since going to New York two years ago, he has been principally engaged on personnel problems to which the war has given special emphasis.

PRODUCTION of motion pictures is no new enterprise in the Bell System, but their direction toward specific training problems in various departments is receiving added impetus as they prove their value in that field and as the training job necessary for post-war expansion grows bigger on the horizon. JOHN M. SHAW, who directs the A. T. & T. Company's motion-picture program as assistant vice president in the Information Department, first joined that department in 1930 after some years of experience in other public services and in the Army in the last war. Since that time he has been general information manager of the Chesapeake and Potomac Telephone Companies and an assistant vice president in the Public Relations Department of the New York Telephone Company—relinquishing the latter post last year to rejoin the A. T. & T. Company.

JOHN M. SHAW

AS A long-time resident of St. Louis, RALPH E. MOONEY has an acquaintance with the Father of Waters which gives him some knowledge of what is likely to happen when a river goes on a rampage—a useful background for the preparation of his article from information supplied by the Bell System companies in the area affected by this year's Ohio River flood. After some years of newspaper and trade journal experience, and service in World War I as a Captain of Infantry, he joined the Southwestern Bell Telephone Company in 1922. In 1924 he became editor of the *Southwestern Telephone News*, moved over to the advertising staff in 1938, and late last year transferred to the Information Department of the A. T. & T. Company, where he has recently been appointed Historical Librarian. He is the author of two novels and has contributed to various periodicals.



RALPH E. MOONEY

By means of the buttons of the key set at her right hand, comparable in purpose to a telephone dial, this outward toll operator sets in motion a sequence of connections which will complete a call directly to a subscriber in a distant city—as discussed in the article beginning on the opposite page

With Peace Will Come a Constructive Program Including the Resumption of War-held Projects and the Development, Extension, and Improvement of Many Services

Looking Ahead in the Bell System

Mark R. Sullivan

Now that V–E Day is behind us and a gradual relaxation of controls over materials and manpower is in prospect, questions are raised regarding Bell System plans for expansion. Forecasts, always subject to the uncertainties of the future, are more uncertain today than ever because of the many unknown factors ahead. Any estimate of the future, therefore, must be considered with full realization of the imponderables inherent in the present situation.

There is one issue concerning which there can be no uncertainty whatsoever. The shooting may be over in Europe, but the war will not be over until the last gun is fired in the Pacific. Until that happy day arrives, the primary duty of every person is to back up the armed forces 100 percent. To telephone workers, the obligation to serve has special significance; for they are entrusted with the responsibility of furnishing the nation with its telephone service—and telephone service is a war essential of the first magnitude. The coördination of military activities, war production, transportation, and every activity of the country depends upon it. The more than 30,000 million calls handled annually speed up all of the social, commercial, and industrial activities of the nation, and thus add immeasurably to its ability to wage war. Telephone men and women are in the fortunate position of being able—short of actually serving in the armed services—to help speed victory by doing their best, day in and day out, on their regular jobs.

Most questions relating to future plans have to do with the kind of projects to be undertaken and the speed with which they are expected to get under way. The kind of projects ahead can be stated with reasonable assurance. The speed with which they will be undertaken cannot, however, be accurately foreseen. The flow of available men, materials, and money and the level of business conditions will control the speed with which the job is done.

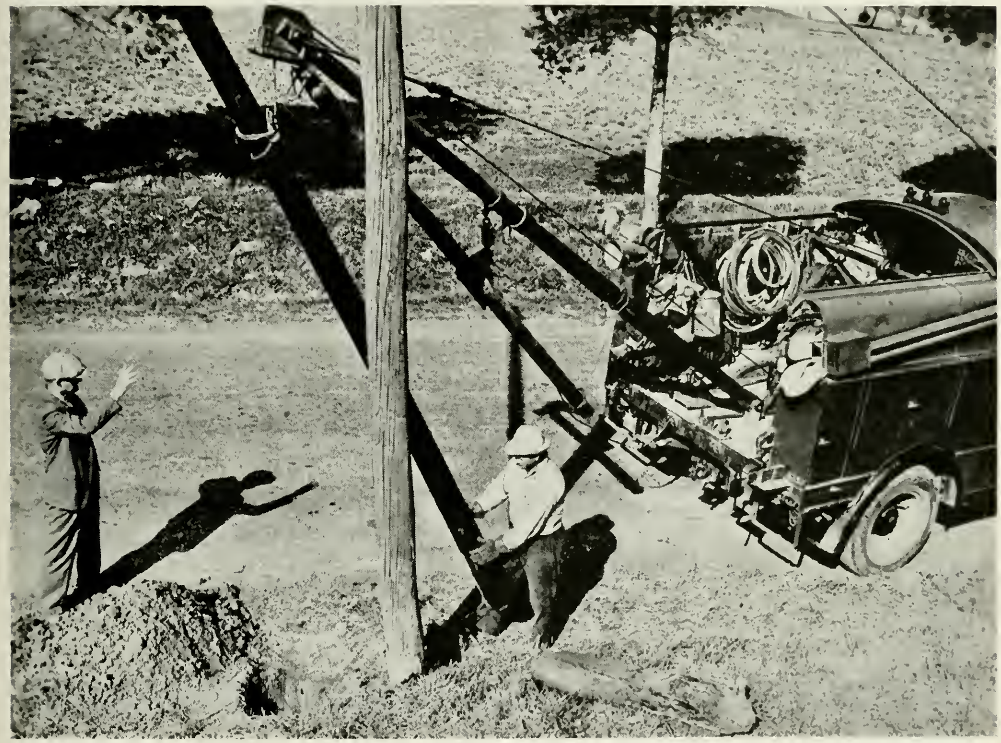
A bird's-eye view of the outstanding projects ahead is as follows:

1. Catching up with requests for services now held in abeyance because of lack of facilities.
2. Catching up with plant shortages to provide for the volume of business presently being handled.
3. Replacements of temporary expedients adopted only for the war period.
4. Providing improved equipment on customers' premises.
5. Strengthening the long distance network, including provision for television and the use of radio facilities.
6. Extension and improvement of rural telephone service.
7. Replacement of manual equipment by dial equipment for local service.
8. Provision of equipment for operator dialing on toll circuits.
9. Provision of equipment for

THE LINEMAN at the left is making a rolled sleeve joint. There will be need for many more circuits in the post-war period subscriber dialing of toll calls where applicable.

10. Extension of service in such fields as service to motor vehicles, overseas telephone service, etc.
11. Provision for growth.

Some details on each of these projects are outlined in the following paragraphs.



A ROTTED POLE is being replaced by one of creosoted pine. Where safety is involved, maintenance has not been neglected during the war

Catching Up With Requests for Service

THE FIRST AIM will be to provide service, without delay, for all who wish it. At the present time the Bell System companies are holding about two million applications for main telephone service for lack of facilities, and so far this year (first half of 1945) the number has been increasing at the rate of about 75,000 per month. In addition, there is a backlog of other requests for service including particularly 400,000 requests for residence extension telephones. To be sure, all of this backlog will not remain firm: many applicants will undoubtedly have moved away or for other reasons will not wish the service when we are ready to install it. What this "melt"—as

Desk-stand telephones, now in use in large numbers, will gradually be replaced by improved instruments such as the combined set shown below

we call it in the industry—may be is entirely a matter of conjecture, but it could well be substantial. On the other hand, there is probably a large demand for services not expressed in our backlog because many people, knowing of the difficulties of getting service at this time, have deferred placing their applications until a more favorable time. Whether the firm backlog turns out to be two million or something higher or lower is speculative, but all things considered, it seems clear that taking care of the backlog will be a project of considerable magnitude.

Clearing Up Plant Shortages

During war-time it has been found advisable to load the plant beyond its normal capacity in order to give the maximum amount of service. This overloading will need to be corrected. Additional central office equipment, particularly dial, will be necessary to restore pre-war speed of service on local exchange calls and to absorb temporary peaks in traffic. Many additional toll circuits will also be required. An increase of approximately one third in the present toll circuit mileage is estimated to be needed to restore pre-war speed of toll service, and we plan not only to reëstablish but to improve upon that speed. Exchange cable plant will be required to make individual lines available to those who wish them where only party line service can now be provided.

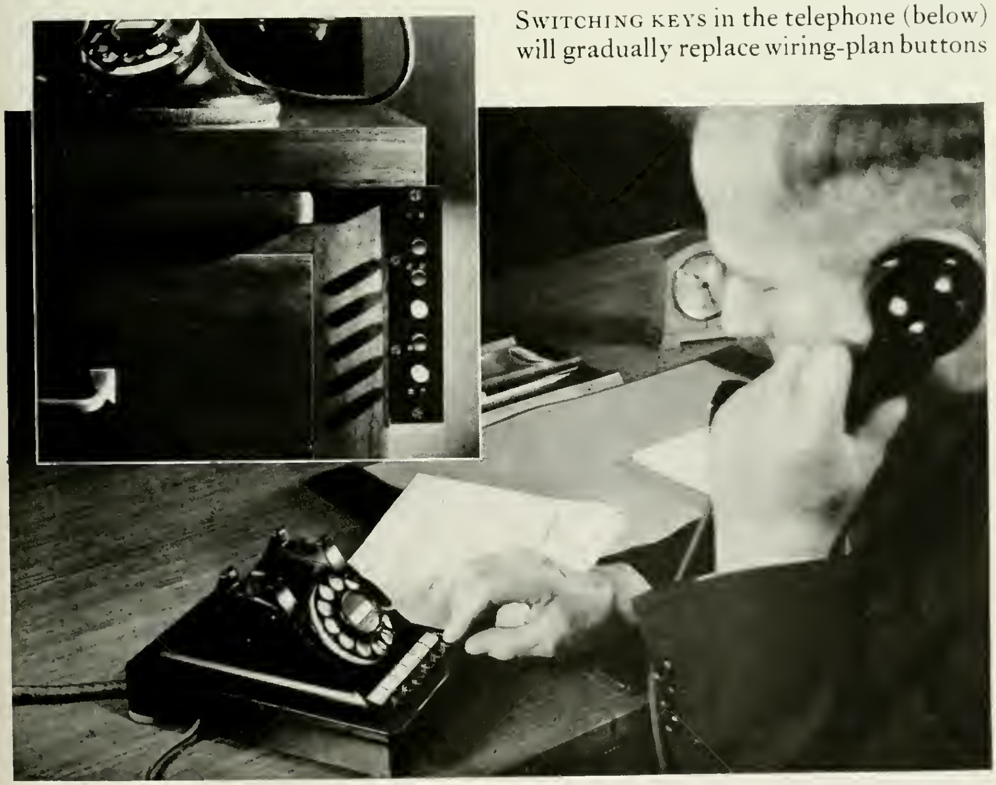
Replacing Temporary Expedients

Some of the expedients adopted during wartime to give the most service with the least manufacture of new equipment and construction of new plant are not satisfactory for continued operation. One item of this nature is represented by 800,000 telephone sets of the pre-war types, which normally would have been junked but which had been saved for the war emergency and put back into service. In some cases, needed extensions of local exchange cable have been temporarily avoided by running pairs of open wire. It will also be necessary to catch up on certain maintenance work which has necessarily been deferred during the war period, and which will involve capital expenditures as well as current expense.

Improving Equipment on Customers' Premises

Before the war, the telephone companies were proceeding with the program of improving the type of equipment on subscribers' premises. Desk-stand telephones were coming out of service at the rate of nearly a million a year. This program will be resumed: there are still about two and one-half million desk stands in service, in addition to those referred to in the foregoing paragraph as being put back because of war shortages. Other improvements in customers' equipment for which, undoubtedly, there will be a demand in the future are dial PBXs in place of the manual PBXs, and key sets in place of the older types of wiring plans with separate keys. New forms of intercommunicating equipment and improved types of colored hand sets will be available after the war. Also, it will be desirable to re-

Switching keys in the telephone (below) will gradually replace wiring-plan buttons



place some of the older types of dials, which are noisy, and to modernize a large number of public telephones.

Strengthening the Long Distance Network

Over the years, the Bell System has tremendously improved its long distance facilities by the gradual installation of a large country-wide interconnected network of toll cables. Much of this cable network—about 70 percent—is underground, and even the 30 percent which is on poles is much less subject to damage by storms and other hazards than open wire circuits on pole lines. There are now about 25,000 route miles of long distance cable in service. Plans have been made for the appreciable strengthening of this cable network by the installation, over the next several years, of about 10,000 additional route miles. The additional cable includes a very important new transcontinental route supplementing the existing transcontinental open wire and cable routes. The new transcontinental cable will cross the southern part of the country, passing through Atlanta, Dallas, and El Paso and terminating at Los Angeles. Another important cable route will be from Chicago and St. Louis south to New Orleans, intersecting the southern transcontinental route at Jackson, Mississippi.

Coaxial cable will have an important role in the expansion of the Bell System's long distance cable network. Here a 1,500-foot reel of cable containing six coaxials is being loaded onto the trailer of the plow train which deposits it, 30 to 36 inches deep, directly in the ground

In these extensions of the long distance network the important backbone routes to be built will be of the coaxial cable type. The coaxial transmission system is so called because it comprises a cable with coaxially arranged conductors (a central wire insulated by discs from a concentric outer conductor). With the addition of terminal equipment and broad band repeaters, it is capable of transmitting frequencies up to several megacycles. In the expected future art, the wide band will provide for transmitting several hundred telephone conversations and one two-way television channel simultaneously on each pair of coaxial units.

The coaxial cable on the main routes will include six or eight coaxial units and in some sections a number of pairs of wires in addition, according to the estimated need for circuits. Thus the plans already made are sufficient to provide the nucleus of a nation-wide television transmission network.

Another type of facility which may also prove important as a means of strengthening the long distance network is the radio relay system. Plans have been made and approvals obtained for the installation, which will go forward as rapidly as possible, of an experimental system of this type between New York and Boston with seven intermediate repeater stations. The radio relay systems will apply in the field of radio an established principle of long distance telephone lines: namely, the insertion of amplification in the cir-

AFTER THE WAR is over, the Bell System plans to resume its active program of extending rural telephone service, with the expectation of rapidly increasing the number of farm telephones cuits at frequent intervals along their length. The very high frequencies to be used in this system require a line-of-sight path for their transmission which will require an average repeater spacing of about 30 miles. The resulting circuits are expected to be suitable for telephone and television transmission. The Bell System is interested in the best type of transmission, whether it be by wire or by radio, and, depending upon the results of the New York-Boston experiment, radio circuits for telephone and television may find widespread application in the Bell System network.

Resumption of Program for Extending Rural Service

BEFORE THE WAR, the Bell System was proceeding very rapidly with the extension of rural service. From 1935 to 1945 the number of rural and service-line telephones in the Bell System rose from 600,000 to a million. Over 80 percent of all farms in Bell System territory are now on existing telephone lines or near enough to be connected without a construction charge.

Nevertheless, many farms do not now have telephone service, and after the war the Bell companies propose to resume their active program with the expectation of rapidly increasing the number of farm telephones. In this program several recently developed types of facilities will be featured. These new facilities include high-strength steel wire making possible long span construction, carrier systems which can be superimposed on either power or telephone lines, and ultra-high-frequency radio.

Replacement of Manual Switchboards by Dial Equipment

PRIOR TO THE WAR, the Bell System was making rapid progress in replacing manual switchboards by dial equipment for exchange service. At the outbreak of the war about two-thirds of all Bell telephones were dial operated. Dial service proved most fortunate during the war because with the manpower and womanpower shortage the present amount of service could not have been given without the dial equipment.

It has been necessary to suspend this replacement program during the war, no new projects of this type—with negligible exceptions—having been initiated since 1941. After the war the Bell companies propose to go forward rapidly with the extension of dial service.

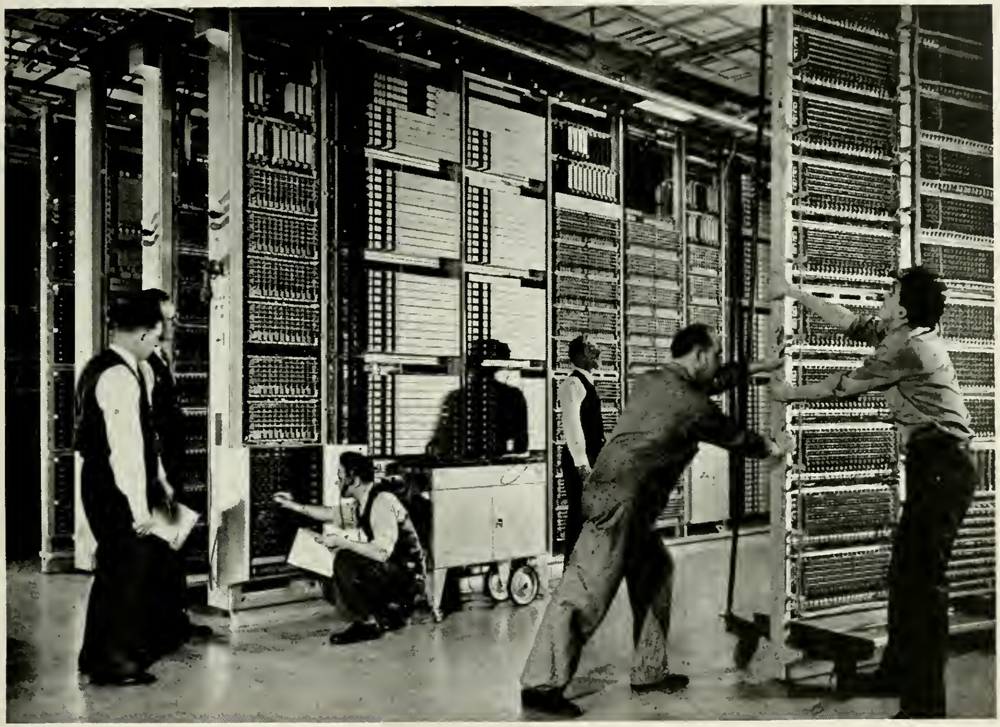
Development of Toll Line Dialing by Operators

BEFORE THE WAR, the companies had made a start in the application of dial equipment on toll and long distance circuits by which the toll operator at the originating end can complete a call to the subscriber at a distant point without calling on the services of an inward or through operator. At the present time about five percent of the toll board calls are handled by this method. Experience with this type of operating, which has been very satisfactory, justifies planning on its further development, and it is expected that the companies will proceed rapidly to equip a high percentage of all toll circuits for operator toll line dialing. By this means, an important further increase in the speed of service will be made.

Subscriber Dialing of Toll Calls

At present there is a certain amount of subscriber dialing of short haul toll calls where arrangements could economically be made for the call to be counted in the registers used for recording local message-rate calls. In these cases the short haul calls are registered as two or three local calls.

This method will be supplemented after the war by the application of developments now under way which provide for automatically preparing a record of a toll call dialed by the subscriber without any help from the operator. Under this system the record automatically prepared will contain all the necessary information for billing, including the calling and called numbers and the length of conversation. It will, therefore, be free from the limitations of the present method, as individual billing of the toll calls is possible. It is expected that this system will have wide application in metropolitan centers.



At the outbreak of war, about two-thirds of all Bell System telephones were dial operated, and the rapid extension of dial service is an important part of the post-war program. This photograph shows crossbar dial central office switching equipment.

Extension of Services—Motor Vehicles, Overseas, etc.

The Federal Communications Commission has been requested to provide, in their allocation of radio wave lengths, for a general radio telephone service to motor vehicles on a common carrier basis. Work looking to the inauguration of such a service in a number of cities is actively under way and it is hoped shortly after the war to make a number of such installations. It is rather early to determine to what extent this will be desirable, but many industries have shown great interest and it is likely that an extensive service will be developed.

The plans under way contemplate not only service in cities, which has been given to a limited extent in the past, but also service on main highway routes. Such services are of interest to truck and bus companies and many others. Within the cities, the service is of interest to taxicab companies, express companies, ambulances, doctors, public utilities, delivery companies, and a broad range of other firms. Radio telephone service may also be given to moving trains.

Before the war, the Bell System gave direct overseas radio telephone service to 31 points, and by switching at these points provided service to more than 70 foreign countries. Plans have been made for a considerable expansion of this service after the war, including additional circuits to the points heretofore served and new circuits to many points not now served directly. With the growing community of interest between nations, the potential capacity for the development of overseas service appears to be large, and it may be that material extensions beyond the present plans will be required.

Also, however carefully we may review the future as we now see it, there are certain to be additional projects making use of inventions to come which will inevitably flow from the tremendous momentum of the research and development work of the Bell Telephone Laboratories.

Growth

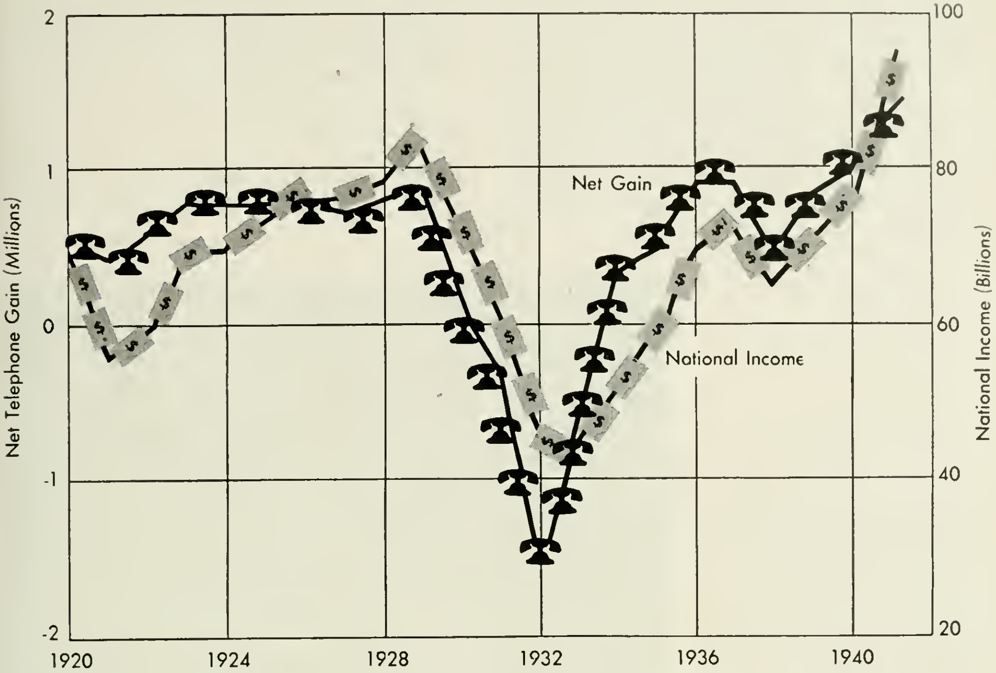
In addition to the projects necessary to catch up with suspended work and to improve and extend the scope of service, the System will need to provide for future growth.

An estimate of future growth at once involves a question of the general level of business activity, which is frequently measured in terms of national income. The chart on the opposite page is of interest as indicating the correlation of net telephone gain and national income.

Many predictions of post-war national income have been published, the figures most commonly quoted varying from 50 percent to 100 percent above the national income immediately before the war. Considerable emphasis is placed on a high national income being essential to servicing the national debt and in the interest of full employment. Surely every effort will be made to have business and government unite to bring about the desired production.

The net telephone growth of the Bell System for the 10-year period, 1935 to 1944, inclusive, averaged 840,000 per year (it would have been over 1,000,000 per year if fa-

NET GAIN IN BELL SYSTEM TELEPHONES, AND NATIONAL INCOME



Note: This chart is not posted beyond 1941 because national income in subsequent years has been distorted by war conditions.

cilities had been available in the war years to connect the applications now in the held-order file). On the assumption of a high national income, it would seem reasonable to look forward to a growth for a number of years averaging appreciably higher than in the past. It is not necessary at this time for the Bell System to make a specific forecast of telephone growth for any long period of time in the future, since the first requirement will be to take care of the backlog of unfilled orders; and after that is accomplished, plans to care for growth can be kept sufficiently flexible to conform with whatever requirements unfold. If the demand for net additional telephones should be as high as that experienced in the last ten years—about one million per year—expenditures for new construction of about $300,000,000 per year will be necessary for that purpose alone and any additional growth resulting from a further stepped-up national economy will add to even that huge amount.

Total Construction

In total, it is clear that the post-war construction will probably be materially in excess of any prior experience, a billion dollar expenditure probably being necessary almost immediately after the war and another billion dollar expenditure probably being required within a very few years. Not all of the projects will be undertaken at the same time. At first the emphasis will be to catch-up on the essentials necessarily suspended during the war period. As this work progresses, emphasis will shift to plant for service improvements and for extensions of services. At the peak of the construction program, it is likely that the expenditures for construction will reach as high as $650,000,000 per year—which would be 50 percent higher than the highest year immediately preceding the war. The question, however, as to when this peak will be reached or how much will be done in any particular year or period can be answered at this time only in general terms, as stated in the foregoing, because it will depend upon how fast manpower, materials, and manufacturing facilities become available.

THIS recent picture of a small part of the Long Lines Department's overseas switchboard is timely as cessation of hostilities in Europe permits resumption of public service to an increasing number of points abroad. After the war, service will be extended to places not heretofore reached

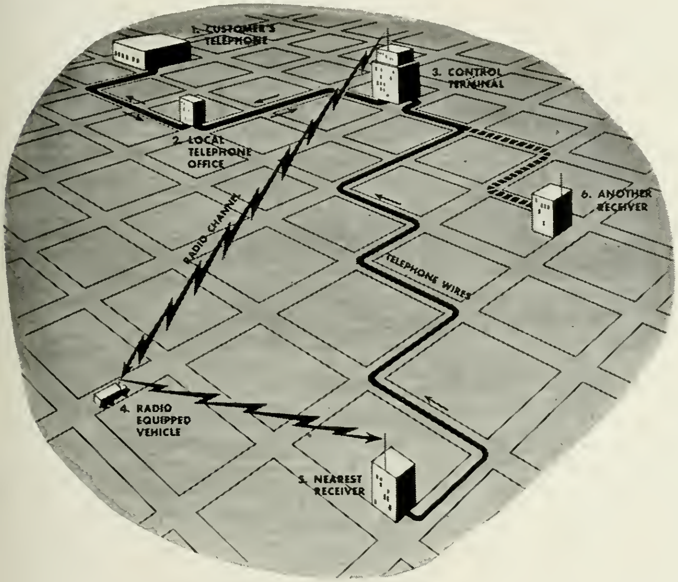
Making Jobs

THIS PROGRAM will create many thousands of jobs. There is nothing in the proposed program that consists of "made work" for the sake of jobs alone. The projects considered are sound economically for the long-term pull and are required to render an essential service. At the same time, they will contribute to the over-all national welfare and prosperity.

These are projects wisely conceived and fully justified and in a strict business sense are capable of providing a return on the capital investment.

The projected program would mean within the Bell System jobs on a large scale. The full impact would be felt immediately in the factories, where the equipment is manufactured, and in the construction forces that build and install the plant. For these functions alone it is estimated that the program at its peak would provide jobs for 70,000 employees over and above the number now engaged in this work.

Then more jobs would be required in the forces that maintain and operate the plant after it is in service. And behind the jobs within the Bell System, there would be many involved outside the Bell System—in the mines and forests from which the raw materials come, in the foundries where the finished materials are forged, in the transportation systems over which the materials and equipments are shipped—in fact, the effects would be felt throughout the national industrial structure. It might be interesting to estimate the number of jobs required for all these purposes, but such an estimate would involve so many variables that it is perhaps more prudent merely to underscore, as may safely be done, that the projected program in total means jobs on a vast scale.



Radio telephone service to motor vehicles, as illustrated in this sketch, would operate as follows: The customer (1) asks for "mobile service," his call going through the local telephone central office (2) to the control terminal (3), where a special operator signals the desired vehicle (4) by radio. When the driver answers, his voice travels by radio to the nearest receiver (5) and by telephone wire to the control terminal (3) and the local central office (2) to the customer's telephone (1)

The program could be temporized in part by resorting to expedients which would defer capital expenditures and postpone jobs for the immediate period. For example, in adding to outside plant—the lines which connect the telephones at the customers' premises with the central office—it is frequently possible to add a few wires to an existing pole line which may be adequate to serve the immediate needs, rather than to put in a cable capable of meeting the needs for some years in the future as well as for the present. For the immediate period, less capital would be required and fewer jobs created, but maintenance expense in the long run would be higher and finally the cable ought to be provided anyway. In brief, some capital expenditures could be deferred but eventually the total expenditure would be greater than if the plant were engineered and installed correctly in the first place. The principle of this simple illustration applies to all forms of telephone plant, including outside plant, station apparatus, and central office equipment.

Getting Money

But why consider deferring construction by resorting to uneconomical expedients? Such a policy would not produce, but reduce, jobs at a time when the most vital need will be jobs—jobs for returning service men and women and jobs for those now in war work. After all:

We know how and where to get the basic raw materials, such as copper, steel, lumber, and all the other things required. If the money is available, we will be able to buy the materials—and go ahead with the jobs.

We have the know-how to convert raw materials into useful and profitable equipment and we are anxious to put that know-how to use—to make jobs.

Manpower will be available, and if we have the money we will be able to hire it—for good jobs.

The one big "if" in this picture is having the money to buy the things and employ the services necessary to apply the know-how which will create jobs. It may seem strange, considering the resources and the financial strength of the Bell System, to raise a question about getting the money to pay for materials and manpower for a program that is in the interest of all concerned. As a matter of hard brass tacks, however, it amounts to just that.

The Bell System's reputation of financial strength is properly deserved. Since 1920—mostly in the 1920's—the Bell System companies have raised additional capital in excess of $2,500,000,000 (excluding refunding). Since we did it before, we ought to be able to do it again. But the Bell System has no magic method of raising money. It must obtain additional capital in competition with everyone else who is in the market for it. The investor takes many things into account in appraising different investments, and it is his appraisal which determines whether we get his money and at what prices. A controlling factor in the investor's judgment is what return will be available to him. The investor, in analyzing the value of Bell System securities, considers the record of the past, the performance of the present, and the prospects of the future.

Therefore, it is vital to the System to sustain its credit position, which is dependent upon its earnings, now as well as in the future, so that it will have the financial strength required for the huge program of expansion which lies ahead. Concurrently an improved telephone service will be rendered to the nation. These dual results will make a contribution in the national interest in keeping with the best Bell System tradition.

Looking ahead, the stage is set for expanding activities; and in the telephone industry the proper marshalling of men, money, and materials will speed up the realization of the much-to-be-desired objective:—more service to the nation, more jobs for its men and women.

Readers who recall "A Review of Army and Navy Communication Facilities," by Myron F. Dull, published in these pages in the Spring of 1944, may be interested to know that the work therein described has won high praise for the increased efficiency and economy achieved in military communications in this country.

In a letter to President Walter S. Gifford of the A. T. & T. Company about the contributions of the Bell System "Communications Committee" which made the surveys and offered recommendations, Major General Harry C. Ingles, Chief Signal Officer of the Army, said in part:

"The Communications Committee, which worked directly with communications personnel of the Army Communications Service, has been the biggest single factor, in my opinion, in the efficient organization of the Army's domestic communications facilities which are now operating on a highly efficient and satisfactory basis, notwithstanding the tremendous increase in traffic volumes. As a direct result of the Committee's work, a great improvement has been effected in the service rendered with large reductions in costs to the government and resultant savings in equipment and line facilities. This Committee has made possible very close coördination between the Army Communications Service and the various Bell System companies, which has been of material benefit in the solution of common problems."

The 60,000 Employees Now in the Service Will Find Both a Warm Welcome and an Integrated Program for Using Their Capabilities in an Expanding Public Service

Welcoming Bell System Veterans Back to Work

Lawrence L. Armantrout

"Jobs for all these employees will be ready for them when their present work is done. Their skill and energy are important assets of the System and will be needed in the big tasks which it faces in the future."

With these words President Walter S. Gifford of the A. T. & T. Company, in his Annual Report for 1944, reaffirmed the basis of the Bell System's program to welcome back more than 60,000 men and women serving in the Armed Forces and Merchant Marine.

The program is three-fold. Each phase is an essential part of the whole. The first is to plan the progress of System operations and the extension and improvement of its public service so that jobs will be ready. The second is to establish and administer a policy with respect to the wages of returning employees, and their credit for service under the Benefit and Pension Plan, which will be fair to each individual and equitable to all. The third is to prepare and carry out detailed procedures leading to the right job assignment for each person and the greatest possible opportunity for him to find genuine satisfaction in his work.

Let us look at each part of this program a little more closely:

Jobs Will Be Ready

As Mr. Gifford has said, the prime fact is that the Bell System will *need* the skill and energy of its returning service men and women in the big tasks which it faces. However, those tasks do not just happen. Rather, they spring from the conception that the job of the Bell System is to render an ever improving communication service, constantly wider and more useful in its scope. Therefore it has been and will continue to be essential for the organization to develop better ways of doing the job, and to apply these improvements in projects which will be fruitful of more and better service on the one hand and greater work opportunity on the other.

Today, in consequence of such long-term enterprise, the System looks forward to a vast amount of useful work. The backed-up demand for telephone service must be met. Plant margins must be restored. Considerable war-built plant must be replaced by new and better facilities. Improved types of exchange and toll central office equipment will be introduced in large quantity. A big program is pending to extend and improve rural telephone service. The long distance cable network will be substantially enlarged. New types of radio facilities give promise of wide application. Overseas radio telephone service will be expanded. Plans for all of these and other undertakings are in progress today. All of them stand behind the assurance to Bell System veterans that jobs will be ready for them when their present work is done.

Wages and Benefit Credits

Early in 1945, each Bell Company employee on leave of absence in the Armed Forces and Merchant Marine was informed that on his return to work within the period specified by the Government, he will receive a rate of pay which will be the same as if he had worked continuously with the Company on the job he held at the time he went on military leave. This means that his new rate of pay will include all increases he would have received had he stayed at work in that job. If a new assignment is necessary or desirable, he will receive the rate of pay appropriate to the new assignment. Each veteran will also receive full service credit under the Benefit and Pension Plan for the entire period of his absence on military leave.

In this policy, as in its entire program, the System expresses its desire to live up to and beyond the spirit of the Selective Training and Service Act and other legislation which covers the employment rights of the veteran.

Job Assignment and Training

Now let us see how the System has planned the actual process of welcoming its service men and women back to work.

Each returning employee wants to feel that his Company is planning for *his* return, is thinking about *him* and the job *he* is going to hold. Likewise, employees on the job at home have a natural desire to give their returning fellow-workers the best possible welcome and to coöperate with them as they adjust themselves to a different way of life. The program of the Bell System Companies is therefore simple and clear-cut: It is to enable each veteran to find his right place on the team, and to set up uncomplicated but thorough procedures so that each part of the organization can translate the natural feeling of welcome into effective action. While the plans of individual telephone companies may differ in detail, all have the same fundamental pattern and look to the same objectives.

Most veterans, it is anticipated, will want to go back to their old jobs. A substantial number, however, will have matured beyond the scope of their former work. Others may wish to change their occupations or the locations from which they entered military service. A few may be unable to resume their former work because of physical disability. In every case, the Company will try to make sure that the employee is assigned to a job which fits his total qualifications—one in which he can make his greatest contribution to the business and feel that he is doing so—and one which will facilitate his adjustment from military to civilian life.

This means that the wishes as well as the qualifications of returning men and women will be carefully considered. Capacities and skills which they have developed as a result of military training and experience will be recognized and used to the fullest extent practicable, both in the initial job assignment and in charting the employees' future career. The veteran who has a physical disability will be placed (and trained where necessary) on a job *which fits his particular qualifications,* not merely on a job he can do.

The Three Major Steps

There are three major steps in the procedure which has been set up to achieve these results. In the telephone companies, the first is to make a "planned tentative assignment" in advance of the time when the employee returns to work. This tentative assignment is based on supervision's knowledge of his qualifications at the time he went on military leave, plus careful study of all available information regarding his military training and experience. The amount of such information that is available of course varies with different individuals, but every effort is made to keep the employee's record as complete and up to date as possible. By definition, tentative assignments are subject to change, and many of them no doubt will be changed. Nevertheless, they focus attention on each individual, stimulate the thinking of supervisors, and help to prevent confusion when the veteran does return. Also, because the majority of tentative job assignments will no doubt become the actual assignments, taken all together they provide information that is invaluable in force planning both by location and by occupation.

The second step is, of course, the actual placement of the returning employee. To assist supervision in placing the right man or woman in the right job, there is generally in each Company an over-all Placement Committee composed of members of each department. These committees help to coördinate the actual work of assignment which is going on from day to day, as for example when a returning employee is assigned to work in a different department from the one he worked in before. They also keep track of results, with particular emphasis on the placement of employees who may be disabled, and give advice and assistance whenever required. Finally, they keep the whole procedure under study and recommend changes which experience shows are needed.

In many instances, the natural person for the returning veteran to get in touch with will be his old boss. The boss will welcome him, sit down and talk with him, and see that he meets all the old and new friends in the Company whom he wants to see. He'll be deeply interested, too, in learning what the veteran's ideas are and what he wants to do.

Next, the boss will usually call on an appropriate "placement representative" to confer with the returning employee and to discuss with him in detail the question of a specific job assignment. The placement representative may be a specialist who functions interdepartmentally, or he may be one of a group of selected supervisors in any department. He has at hand all the information developed in the preliminary plans for the veteran, and is closely familiar with job opportunities in the department or Company. Together, he and the veteran now review all the facts in order to arrive at a job assignment that will be agreeable to the employee and to the Company. During the interview a complete record of the employee's military service is secured and made a part of his permanent personnel record.

As AN AID in finally making the proper assignment, the returning veteran will ordinarily have a medical examination. The placement representative arranges for this and keeps in touch with the medical examiner. From the employee's standpoint, as well as that of the Company, it is imperative that he should not be asked to perform work beyond his physical capacity. Objective data are available concerning the physical requirements of different jobs, and these are helpful in the study of what may be the best assignment for an employee who has some physical limitation. Decision not to reinstate an employee because he is not physically qualified for *any* job can be made only by a Company officer after complete interdepartmental review.

When the placement representative and the returning veteran have worked out what looks to be the right assignment, it is then recommended to appropriate management for approval. Responsibility for the decision, as for the employee's happiness and progress from the time he goes on the job, rests with the supervision under which he is to work. The function of the placement representative has been only to assist supervision, not to assume its responsibilities.

The time when the veteran is to start work will depend entirely on his own wishes. It may be the same day he first comes in. (Incidentally, this indicates the simplicity of the procedure at the time of his arrival. A prime reason for all the preliminary work that has been done is to make sure that the proper assignment can be made promptly.) Or he may prefer to start at some reasonable time in the future.

IN THE third phase of the veteran's return to Bell System work, his supervisor, as already indicated, has the key responsibility—and opportunity. Through his own ability, his understanding, his capacity for leadership, he can make a contribution of the utmost importance in assisting returned employees to find satisfaction and happiness in their work.

The person who returns from military service will in many instances come back a different man from the one he was when he left. He has been trained for a very different kind of job and has led a vastly different life. His activities, discipline, aims, and friendships have all been unlike those which filled his civilian life.

The situation to which he returns will at least in some degree seem changed. This may be true with regard to his work environment, as well as to conditions at home, even though he is assigned to his former job. Conditions of living generally will have changed. During his absence he will have remembered things as they were, and he may have built up a rosy picture of the life he would come back to. Reality may fall short of these expectations.

It will be necessary for each person coming back to reconcile these differences. Most men and women will make the adjustment in time. Many will make it quickly. But it will be harder for some than for others, depending partly on temperament, age, and military experience, as well as on such factors as family, friends, and environment.

The supervisor can assist the employee to make this change successfully in a reasonable time. Re-orientation training to inform the veteran about what has happened while he was away, and re-emphasis on safety, quality performance, good public relations, and the like, will help him to feel at home again in the telephone work situation. Refresher training, tailored to his individual needs, will help him to put his old skills to work again—and his new ones too, so far as possible—so that he can make up for lost time.

It will be the responsibility of supervision to see that the employee obtains all the advantage which such training can afford. The supervisor will be alert, also, to the employee's progress on the job, and in any case where it appears that the job assignment is not working out as expected, he will take constructive action. In ways such as these, the supervisor will make his essential and continuing contribution toward the fulfillment of the Bell System's program for all its returning service men and women.

The System is proud of those men and women. It can find no more appropriate way to honor them than to plan and carry out effective procedures for welcoming them back to useful work that needs doing.

IF THE TRADITIONAL American way of life continues, the present level of living—both material and intellectual—should continue to improve within the limitations set by human frailties. In this American experiment the Bell System intends to provide a living and a good life for the people who are in it, and a constantly improving service to the rest of the public in their pursuit of happiness. The way in which we make a living is the day-by-day practice of democracy. It is the essence of the American experiment. To be an effective part of this greatest of all human enterprises is the part which the Bell System hopes to continue to play.

From "The Bell Telephone System," by Arthur W. Page, Vice President, A. T. & T. Co. Harper & Brothers, publishers, 1941.

Films Will Have an Increasingly Important Part in Training Bell System Men and Women in the Skills which They Must Acquire to Handle Their Jobs Effectively

The Blackboard Comes to Life

John M. Shaw

"Where do films belong in Bell System training, and how shall we go about making and using them?"

Many people have been asking this question of late, in many parts of the Bell System. They have been arriving at the answer by the very practical process of trial and error. Let us begin this discussion by telling a few stories about the use of films by telephone people.

PORTRAYING ELECTRICAL APPARATUS

A few years ago certain equipment was developed for use in central offices which was both new in principle and complex in operation. Plant forces in one of the larger cities found that the equipment could be understood by the men who had to install and maintain it only after a long and difficult course of training. Using an amateur 16 m/m motion picture camera, the plant training staff animated and photographed drawings of the new equipment in such a way as to make its electrical characteristics clearly apparent. The principle of its operation was described by pictures on the screen before the class to amplify the spoken words of the instructor. By the use of this home-made teaching device, the men were better trained than first seemed possible, and in half the time.

CLARIFYING A CLERICAL PROCESS

One of the Bell System's revenue accounting centers worked out a new time-saving method of assembling cash stubs and applying payments to customers' accounts. Results indicated that extension of the new method throughout the System would offer an opportunity for some substantial conservation of money and manpower. The handling and processing of these stubs is a manual job, and is not easy to describe in words alone. The new method, to be fully understood and appreciated, had to be demonstrated. A slow-motion film of two experienced workers was made, from which every detail of the process could easily be seen and followed. This film was sent to accounting people throughout the System, thereby assuring a correct understanding of the new method and making available an effective training aid. A number of companies have now adopted the new method and given testimony to the training value of this film.

Technical accuracy is a "must" in Bell System film-making

SHOWING HOW OTHER DEPARTMENTS WORK

The Commercial people who man the Bell System's business offices are properly known as "representatives" because they are called upon to interpret the operations of every other department in terms that the customer will understand. The need for giving large numbers of new people this background came at a time when the business offices were faced with their heaviest loads and when shortage of facilities made public understanding particularly difficult to secure. This presented a wartime challenge to test the ingenuity of the best instructor. Individual visits to other departments were out of the question. Using a new training technique that combines motion and still pictures, one company set out to describe, in a series of films, the operations of Plant, Traffic, and Accounting departments as they touch the customer. Most of the Bell System's ten thousand Commercial representatives have since received this training.

HOW TO CLIMB A POLE

The climbing of a pole is a skill that has to be constantly taught to succeeding generations of telephone linemen. There is a right way to climb a pole, and there is a wrong way: a safe way, and an unsafe way. The right way calls for a rhythmic coördination of arms and legs, and for dexterous manipulation of climbing irons and safety belt. These things can only be learned by practice. But unless the new lineman gets off to the right start under the watchful eye of a skilled instructor, he may become habituated to the wrong way. An ingenious Plant supervisor exposed thousands of feet of color film showing a highly-skilled climber going up and down a pole. He then had a sound track applied to the film, with a professional narrator describing each movement and the reason for it. The lineman-in-training may now see how an expert climbs a pole when he is at his best. He sees the right way again and again, from every angle and from every position on the pole. The consequences of doing it the wrong way are dramatically brought home to him by the enacting of a serious accident. More than fifty prints of this film have been used by Bell System companies.

DRAMATIZING EFFECTS OF CARELESS WORK

With the unusual number of new operators occasioned by the war, the Traffic people observed a disturbing increase in errors on toll tickets. A sound slide film was made which showed in dramatic fashion the inconvenience and loss that result to other departments and to telephone users by a slight error in noting the time of a call or the number of the called or calling party. The film was shown with good effect to toll operators in many Bell System companies.

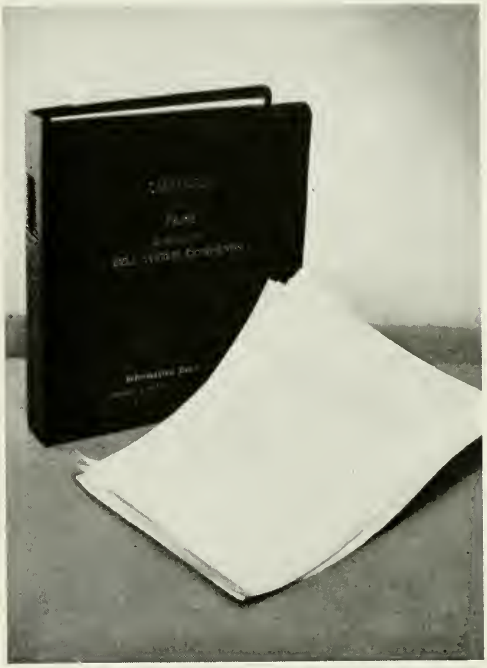
STIMULATING INTEREST IN PENSION PLAN

One of the companies dramatized its benefit and pension plan on a sound-slide film, and was thus assured of the undivided attention of all employes to this important matter for at least fifteen or twenty minutes. Several other companies have since adapted this film to their own purposes. When policy questions are involved, such films have the advantage of insuring uniformity of presentation combined with a dramatic forcefulness that is difficult to achieve just through writing or talking.

MAKING A HUMDRUM JOB INTERESTING

Western Electric's war-time job called for the packing of vastly more equipment, with fewer experienced packers to do it. New people, many of them women, had to be taught to drive nails. A highly skilled nailer was photographed in film. Step by step, every detail of nailing a packing case was pictured. World Series movies were spliced into the film to show that the swing of the skilled nailer has the same basic motion as the swing of the champion batter. In dramatic narration, it was made clear that winning a war means driving nails as well as pulling triggers. The film not only shows how nails should be driven, but makes the audience *want* to go out and drive nails. Now every nailer at the Kearny plant sees "Hit 'em on the Head" as part of his basic training.

It would be possible to fill twenty pages and more with similar examples of films produced by Bell System people to supplement specific training programs. At least as many more could be filled telling of films made outside the Bell System and applied to our use. A catalogue has recently been issued by the Motion Picture Division of A. T. & T. listing and describing these films.



Nearly 200 films are listed in this new Bell System catalogue

Scope and Purpose of Training Films

The use of films in training programs, in the Bell System and elsewhere, has been handicapped somewhat by a misunderstanding of their scope and purpose. Advocates of visual training in the educational field have at times made promises that present equipment and skills could not fulfill. Films have sometimes been crudely made and inexpertly used. Training people, seeing the new device at its worst, have

TITLE FRAMES of some of the motion pictures and slide films produced by Bell System Companies

in such cases been discouraged against further experiment.

These are but the natural obstacles that every new technique encounters in the process of finding its place and proving its worth. To overcome them, it is well to view them in their proper perspective.

The Board of Education does not fire the teacher nor lower the educational requirements of its teaching staff because the school acquires a new and better blackboard. Neither should the training film be thought of as enabling a training job to be done with unskilled instructors. The film does not replace the instructor. It doesn't even replace the blackboard. It is nothing more than an ingenious tool which under certain conditions the instructor may use, very much as he uses the blackboard, to make his teaching more effective.

Instead of drawing a crude diagram or picture on the blackboard, the instructor flashes the diagram or picture on the screen, bringing to his aid specialized skills that he himself does not possess—the skills of draftsman, artist, photographer, actor. Instead of describing by word and gesture how an object moves, the instructor shows the object itself moving on the screen. Instead of attempting to describe the sound made by the object, the instructor brings the sound itself into the classroom and reproduces it *exactly* for the benefit of his students.

The skilled teacher uses the blackboard as he talks, thus reaching the mind of the pupil through the eye as well as the ear. In much the same way, the skilled teacher can use film to illustrate and amplify his instruction. The film thus tends to become an integral part of the teaching process rather than an appendage to be used to give the instructor a breather if time permits.

Experience in the Bell System and elsewhere indicates that films have certain advantages which have already been partially realized but which we may expect will accrue in ever-increasing measure as the techniques themselves are improved and instructors become more skilled in their application.

Advantages of the Film Technique

THE BASIC ADVANTAGE of the use of pictures is the general one that the mind is reached through an additional sense—that of seeing. But certain specific benefits are also worthy of mention.

Things which lie beyond the horizon of normal vision, such as hidden parts of an intricate machine, can be brought out and clearly shown from any angle. They can be cut apart and shown in cross section. They can be shown in relation to other parts with every extraneous section of the machine rendered invisible.

Physical things that are very small can be enlarged a hundred or a thousand times and made clear to a large class simultaneously.

Operations too fast for the eye to follow can be slowed down and watched in detail.

A story can be told in carefully chosen language and, once the best arrangement of words and emphasis is determined upon, this high standard is maintained uniformly.

Discussion is stimulated.

Diagrams can be made to come alive to illustrate principles or operations.

Motions otherwise invisible, such as the flow of a current, can be portrayed, simplifying instruction of difficult subjects.

EACH of these films met a specific training need of one or more Bell System Companies

The entire class can see the object under discussion from exactly the same angle as the instructor sees it, whereas in actual demonstration the object is seen from many angles.

Prosaic situations can be made dramatic, professional actors of high skill being at the beck and call of every instructor at every session of the class to help him combat monotony.

A change of pace is afforded the instructor, his energy and time are conserved, and thus his full skill can be brought to bear on that part of the classroom work which can only be done by personalized instruction.

Films can help in the teaching of telephone jobs as basic as climbing a pole —

Supplementary training can be done in cases which may not seem to justify the full-time use of competent technical instructors.

Where visits to distant places to view field operations, or the functioning of other departments, are impractical, these distant scenes can be brought into the classroom.

Music and color can be used when these will contribute to either understanding or interest.

Attention is concentrated, and external distracting influences removed.

The student experiences emotionally the significance of the lesson that is taught.

Entertainment can be added to instruction, making films welcome at social gatherings where other forms of teaching may be out of place.

The impression that a good or bad job creates on customers or other employes who are unseen can be brought forcefully to the attention of the employe in training.

As a result of these general advantages, students learn more thoroughly and quickly; once learned, the message is retained longer.

Limitations of Film Techniques

The advantages of the film techniques will be more quickly achieved if we understand also their limitations. These are for the most part limitations of projection rather than of production, and they exist to greater degree to the extent that motion and sound are desired.

The room must be darkened, at least partly.

The projector must be placed some distance from the screen, as a result of which the instructor is usually at the front of the room and the projector at the back.

The projectors, particularly in the case of sound-motion, are somewhat complicated in their operation; and if they break down, as happens all too frequently, they are not easily put right again.

There is great variation in the projectors of different makes. Some have poor sound but good optical characteristics. Some have poor optical characteristics but good sound.

If motion is used, the film cannot be stopped once it is started moving through the projector, so that class discussion is not feasible as the film progresses.

If it is desired that a picture or diagram be held on the screen, then motion is impossible unless two projectors are used.

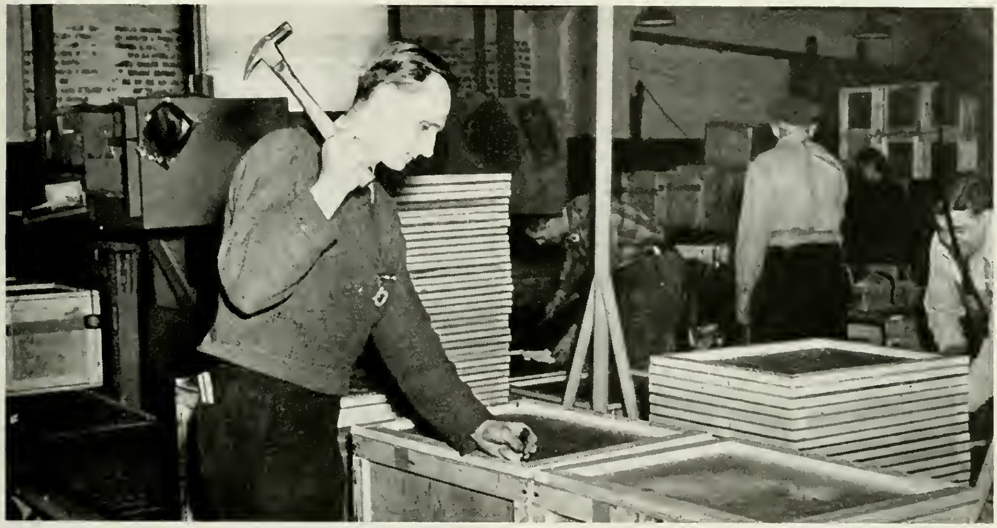
The projectors are quite heavy and not easily portable.

The initial production of a film is usually a long and costly process.

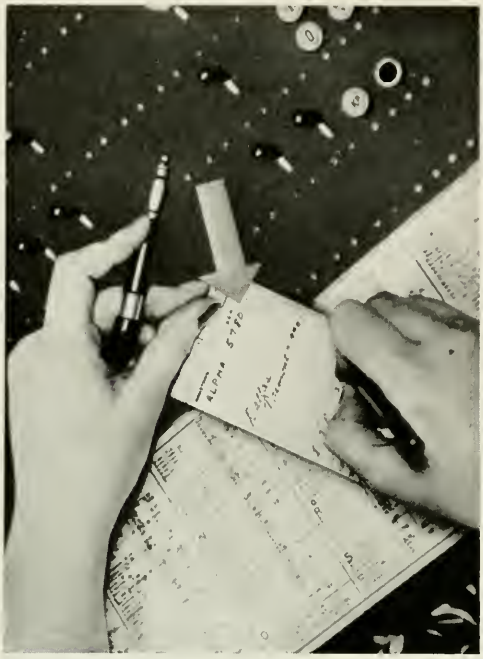
Merely to contemplate such limitations tends to discourage all but the most adventurous teachers. Especially is this so in the Bell System, where so much of our training must be done with very small groups at widely scattered points.

Yet the more far-seeing among those who have made use of films recognize that the projection equipment now available is at best an adaptation of equipment developed for the entirely different purpose of mass entertainment. Manufacturers, however, are already turning their attention to the design and development of sound motion picture equipment more adequate for teaching needs.

What is wanted, so that these limitations may be overcome, is a dependable projection unit that is small, light, sturdy and easy to operate. It should be able to project motion pictures, still pictures, sound, silent,



— driving a nail —



— writing a toll ticket —

or three dimensional. The instructor should be able to stop the machine at any point, either shutting it off or holding a picture indefinitely on the screen. He should be able to control it from his position before the class. If he wishes, he should be able to place the equipment on a desk or table and use it to instruct two or three students at a time. The pictures should be as clear in the light as in the dark. The sound should be audible to a small class, without interfering unduly with other activities in progress nearby.

Is this the expression of an unattainable ideal? The telephone teacher may be excused for hoping it is not, confronted as he is with what has been done in making realities out of the dreams of radar, television, high-speed photography, and other developments that have their roots in the same basic principles as has the training film.

Physical Characteristics of Film Techniques

THERE ARE four methods of film projection in common use.

The sound motion picture. This may be produced in either 35 m/m or 16 m/m film, but for classroom purposes 16 m/m is usually more practical. The 16 m/m sound projector weighs from 30 to 90 pounds, and costs from $150 to $500.

The silent motion picture. Sixteen m/m film without sound track is used when sound is not necessary or when the instructor wishes to discuss the film as it progresses. The 16 m/m silent projector weighs from 10 to 40 pounds, and costs from $50 to $200.

— sweeping a floor —

The sound-slide-film. This consists of still pictures produced on a strip of 35 m/m film. The sound is put on a disc record and is synchronized with the film by the operator, who pulls a cord to change the pictures. The sound-slide-film projector weighs from 35 to 50 pounds, and costs from $75 to $150. It can be effectively used with audiences up to a hundred. Smaller and cheaper projectors are available for use with smaller groups.

The silent slide-film. This may be used when sound is not necessary or when the instructor wishes to speak to his class as the pictures appear. The projector weighs from 10 to 20 pounds, and costs from $10 to $150.

Various other types of visual aids have been found effective, such as stereoscopes, opaque projectors, and glass slide projectors, but these are beyond the scope of our present discussion.

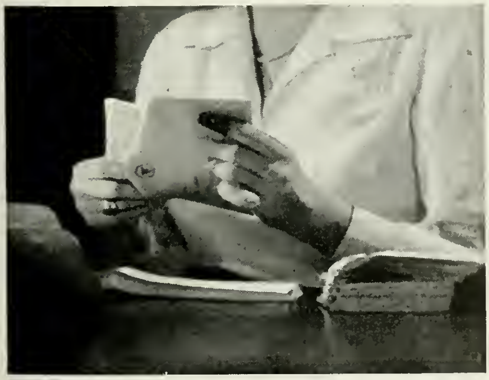
Costs of Film Techniques

A SOUND-SLIDE-FILM, depending on length and subject matter, may cost any amount from $500 to $10,000 to produce, and thereafter the units of film-and-record will cost from $5 to $10 each.

A 16 m/m sound-motion picture may cost any amount from $5,000 to $50,000 or even more, and thereafter each print will cost from $15 to $100.

These costs have been a very real deterrent to the use of films. They are much higher than the costs of the simpler visual aids for which the films may be substitutes. Such costs will seem unjustified if use of the film is restricted to a rather small area, or if it is viewed as an appendage to the training program which can be easily dispensed with.

But when these costs are viewed in relation to the whole cost of a wide-



— enclosing a bill —

using a ladder

spread training program, they appear in a different light. A $5,000 or a $20,000 motion picture, with a life of several years, may be a source of great economy if it results in doing better and faster a training job that costs $100,000 a year in the time of workers and instructors.

One of the silent slow-motion training films now being used by Bell System Accounting people was produced at a cost of less than $1,000. It was admittedly experimental. Otherwise, for an expenditure of five or ten times that amount, it might have been done in sound and color, and with dramatic effects designed to make the new employe *want* to do the job as well as *learn how* to do it. It has been estimated that the universal adoption of the method this film teaches might save the Bell System as much as $250,000 a year in operating costs. It is of course sound economy to spend as much as may be necessary to get the maximum in training effectiveness from such a film.

It is just a matter of good business to subject every contemplated training film to an analysis of this nature and, when the film is in use, to measure its worth in terms of the net cost and effectiveness of the unit of training it is intended to influence.

Experience of the Armed Services

INTEREST IN training films has been greatly stimulated by news of their use by the Army and Navy. The full significance of this development is not likely to be known until the war is over and the whole story can be told. But we do know something about that story already.

With many millions of men to be trained well and quickly, both the Army and Navy turned to visual aids of all kinds to help them. The film technicians—writers, directors, cameramen—who were not brought directly into the service were likely as not to find themselves working for independent producers under contract to make films to be shown to soldiers and sailors. A recent survey showed that 29 of these producers had made nearly 6,000 different reels or film strips for the Armed Services. Hollywood too has given its best skill to the war effort.

The soldier still learns to shoot by shooting, as in all other wars. But in this war he is introduced to the Army by indoctrination films. Morale films keep him fighting. And when at last he is mustered out, Uncle Sam's fond farewell will no doubt be spoken to him on a sound track.

Meantime film helps in the process of teaching him how to conduct himself as a soldier. If he is illiterate, the Army uses film to educate him. He learns by film how to take care of his rifle and film teaches him the dire consequences of his failure to do so. Whatever his special job, part of his training is likely to be done by film, whether it be stringing wire, firing an anti-aircraft gun, or shooting from a fighter plane against a darting Zero. The Navy dive bomber shoots camera and machine gun together so that pilots in training may see what he sees. The soldier is taught by sound pictures how to keep from being hurt, and how to take care of his own wounds and the wounds of others. If he loses a limb, film plays its part in the long process of rehabilitation.

The Signal Corps cameraman goes with the troops, and battle scenes are brought home to teach the strategists the facts of an ever-changing warfare. As new weapons are developed, they are filmed for the better understanding of those who are to use them.

The significance of all this to the Bell System is not only the suggestion it gives of more extensive use of films in telephone training. It is also that a very sizable nucleus of this Army and Navy will be coming back to us some day. To the extent that the stories that have been reaching the home folks are true, it is likely that these telephone men and women will want to train and be trained by techniques that include the judicious use of films.

The Outlook for Films in Bell System Training

We have already seen that the returning veteran will not find the company he left behind him entirely lacking in examples of skillful use of films in training. He will find also a ready willingness to learn anything he has to teach us about it, based on his own experience. Here are some of the things he will find.

ACCOUNTING DEPARTMENT

A Bell System executive in the field of revenue accounting had this to say in a recent memorandum:

"Since many of our routine operations involve the handling of large volumes of tickets, stubs, etc., the facility with which these records are handled assumes very important proportions. For example, we are now issuing approximately 15 million bills each month, which include among other things the charges from approximately 70 million toll calls. Those 70 million tickets must be arranged for billing, entered on toll service statements, and totals obtained. The 15 million bills must be prepared, payments credited, and many other operations performed each month as a routine procedure. Therefore, the manner or technique followed in the manual handling of this volume of relatively small pieces of paper is of prime importance.

"In view of the fact that the performance of this work is dispersed in many offices, it is our feeling that the visual presentation by moving pictures of the best known technique for performing each mass production operation will prove of real help to the Associated Companies."

Since this memorandum was written, a number of experimental films have been made by methods people in the accounting departments. They have proved worthwhile, and the experience gained by their use will no doubt lead to more and better films of this nature.

COMMERCIAL DEPARTMENT

Early in 1945, a group of men from various Bell System companies gathered in New York to confer on film techniques in the training of service representatives. These men had previously made detailed studies "covering each step in the initial and continuation training of service representatives to determine opportunities for the use of films and other aids as a means of strengthening training, reducing the amount of time required, or making training more interesting."

In the meeting, these opportunities were discussed in the light of experience with films and other aids, and a complete report was prepared from which the following is a quotation:

"The need was recognized for taking full advantage of the uses of films where they would help to increase representatives' understanding of the job, develop management point of view, promote confidence in explanations to customers and good judgment in the handling of contacts, and reduce the very substantial period of time now required for initial and continuation training. However, it was agreed that there is much still to be learned before the field for use of films can be fully determined.

"It seemed evident that films would serve primarily as an occasional means of reinforcing existing training, rather than as a substitute for any of the basic training processes. To provide such reinforcement, it appeared that films would have to accomplish one or more of the following objectives:

"Better understanding and retention of the knowledge taught, with resulting better performance on the job and less need for retraining and supervisory assistance following assignment.

"Saving in training time through securing more efficient presentation of material than can be obtained by discussion, demonstration, or visits to other departments, and reducing subsequent questions by students as a result of better understanding.

"Improving training from the student's viewpoint by making it more interesting."

A corner of a typical Bell System Company film library

The report described seventeen subjects offering possibilities for the use of films in Commercial training and recommended that companies planning to undertake the production of films give consideration to these subjects.

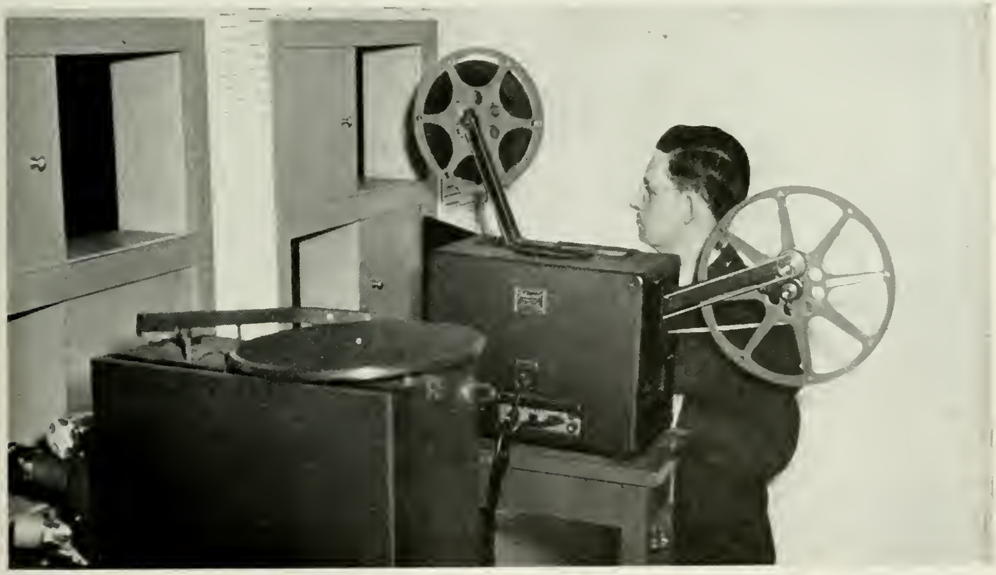
PLANT DEPARTMENT

THE PLANT DEPARTMENTS of Bell System companies have made extensive use of films in training. Films have been especially useful in teaching safe practices and in training foremen in the principles of good supervision.

There are those who believe that it is in Plant work that films can realize their greatest value. As in other departments, "learning by doing" has been and must continue to be the fundamental of Plant training. But since the use of tools and machines is involved, calling for highly skilled craftsmen working on a great variety of tasks, there are many opportunities for the use of films all through the training process.

A preliminary study has just been completed in an attempt to appraise the extent to which films may be used to supplement "learning by doing" in Plant work. The training assignments in four selected crafts were thoroughly analyzed so as to select those in which real benefits could be obtained by the use of training films. The crafts studied were (1) cable splicing, (2) maintenance of central office frames, (3) station installation, and (4) line and cable construction. The areas in which these crafts were studied have training situations typical of those existing generally throughout the Bell System.

It appears that training films might be used to advantage in from 30 per cent to 56 per cent of the assignments in these crafts, and it is probable that some experimental films may follow as a result of the study.



A COMPANY PROJECTION BOOTH: Slide film projector on the left, 16 mm. motion picture projector on the right

A technical consultation during the making of the slide film "Teamwork Against Trouble"

A profitable field for the use of films may be found in the introduction to Plant forces of new telephonic devices. It has always been recognized that it is important not only to design and develop such devices but to interpret and explain them in terms that can be uniformly understood by the thousands of people who must install and maintain them when they are ready to be put to public use.

In making these things publicly useful, it is necessary that the interpretive and explanatory tools be themselves understood, and that they be of the best quality. The tools include such things as charts, blueprints, written instructions, and training manuals.

It is now beginning to be recognized that film is itself one of these tools. In looking into the future, it is not difficult to envision a day when the men who design telephone equipment, and those who prepare the specifications for its installation and use, will think in terms of film as naturally as they now think in terms of these other explanatory devices.

TRAFFIC DEPARTMENT

The Traffic Department has less occasion to use the classroom technique than any of the other telephone

IN A HOLLYWOOD STUDIO during the filming of the motion picture "Voices of Victory"

operating departments. It has the best possible training device ready to hand in the switchboard itself. Individual instruction has thus been brought to a high level of efficiency, with most of the training being done with one, two, or three operators at the most.

Nevertheless, there is great interest in training films in this field, particularly for their value in bringing to the operator a knowledge of the work of other types of operators, and for the introduction of new methods in those special cases where large numbers of operators must be given instruction in a short period of time. Films also appear to have value in the training and development of supervisors and their further use in this field is under consideration.

The inspirational and morale-building film has been used very widely in the training of Traffic people. "Voices of Victory"—a Hollywood-made motion picture—is doing yeoman war-time service. The new picture, "The Calls That Cure," depicting telephone service in war hospitals, is now being used to illustrate the value of the operator in the war effort. And at the suggestion of Traffic training people, a similar theme has been given emphasis in

"Plan for Disaster," the film that tells the story of the 1944 hurricane.

Similar in nature are the films designed to secure coöperation in such important matters as ticketing accuracy, by showing dramatically the adverse effect that errors can have on customer attitude.

A lecture prepared by the Long Lines Plant Department, designed to improve operator coöperation in caring for the equipment she uses at the switchboard and thus conserve manpower in war-time, is now being adapted, in coöperation with Traffic people, to the sound-slide-film technique. This will expand its usefulness and relieve the skilled central office maintenance men who otherwise must be depended upon to deliver the lecture in person.

The Rôle of the Information Departments

There has been a growing need for centralizing the production and procurement of training films in the Bell System. By mutual consent, the Information Department has usually been assigned this responsibility. Not only have its members had much experience with making and distributing films for public showing, but they are skilled in the graphic arts that are a part of film-making. It will be their task to keep abreast of the development of film techniques, to bring these techniques to the attention of training people in all departments, and to assist in the production of such films as training people may decide to be desirable.

Messenger of Sympathy and Love
Servant of Parted Friends
Consoler of the Lonely
Bond of the Scattered Family
Enlarger of the Common Life
Carrier of News and Knowledge
Instrument of Trade and Industry
Promoter of Mutual Acquaintance
Of Peace and of Goodwill
Among Men and Nations

Inscription on the façade of the City Post Office in Washington, D. C.

The Telephone Companies along the Ohio Proved that They Had Learned Much about Combatting High Water When a Mighty Flood Occurred Last March

Outwitting a River on a Rampage

Ralph E. Mooney

"Me and the telephone is leaving!" So said the proprietor of a Bridgeport, Ohio, filling station as flood waters drove him from his place of business. His few words tell succinctly what happened along the Ohio this Spring when Bell companies, short-handed on account of the war, took the unusual course of broadcasting appeals to customers to rescue telephones and bell-boxes in danger of a wetting.

Dwellers along the Ohio River watched with misgiving as heavy rains melted the snows of an extraordinary winter and brought the third-highest crest on Weather Bureau records, early last March. Everyone knew that in face of war shortages it would be disastrous if the region suffered losses like those of 1937, when the father of all floods swept the Ohio and Mississippi valleys. Telephone people, in particular, knew that any losses suffered in equipment could be replaced only with the greatest difficulty. But the flood came—and passed—and for several reasons 1945 did not turn out like 1937.

One reason was the public endeavors to prevent flood damage which had been under way since the earlier flood. This year's water was partly impounded by seven conservation dams on the Allegheny and Monongahela and a series of dams on the Muskingum. Furthermore, the Tennessee Valley system, though not complete, functioned effectively to reduce the crest on the lower reaches of the Ohio. And sea walls built since 1937 at many towns—notably Wellsville and Ironton in Ohio and Tell City and Jeffersonville in Indiana—also proved successful in keeping out the river.

Flood walls and regulation of the

water level prevented damage to much telephone equipment, of course. But still more equipment was saved by the telephone companies' own defense measures, taken during the past eight years in anticipation of the possible recurrence of severe and damaging floods.

For the Bell companies along the Ohio, Mississippi, and other rivers engaged in much soul searching after adding up the losses of 1937. They found some consolation in the sterling achievements of engineers, operators, linemen, and repairmen in keeping essential lines in service during that emergency. Gratifying, too, were the commendations received then for assistance rendered by telephone people to the Red Cross, Coast Guard, and other relief and rescue agencies. But no one could feel that these were honors to rest on. A program to safeguard against future losses was launched at once. The Bell System always has valued foresight above hindsight.

Offhand, the control of damage to telephone equipment from floods might seem to be a matter that Sherlock Holmes would dismiss as "elementary, my dear Watson." If a river occasionally submerges switchboards, telephones, wire and cable lines, why not move them above high water mark? At least since Noah's day, hilltops that floods never reach have been available; why not put the telephone buildings and lines up there? But it is not that simple.

River towns exist because of the rivers. They are ports. Not only do they handle freight from steamboats and barges, but the silted plains about them often are found to be valuable industrial sites, with the advantages of rail and water transportation. And if a port or manufacturing center exists, it must have telephone service, local and long distance. Therefore, only a certain amount of equipment can be taken to high locations. What remains in the lowlands must be protected by various means.

Long Lines' Protective Measures

In the Ohio and Mississippi valleys, the Long Lines Department of the American Telephone and Telegraph Company since 1937 has rebuilt lowland lines with more than 1700 poles tall enough to carry the wires and cables above high water. Some of these lines already have been tested two or three times and have stood firm with their wire loads safe above acres of water. Long Lines also relocated about 30 miles of lines on higher ground and rebuilt a river crossing near Murphysboro, Illinois, to provide greater clearance from flood water. At Louisville, Memphis, Alexandria, Cincinnati, and Portsmouth, long distance entrance cables were put under gas pressure so that even when they are submerged the gas will prevent water leaking in through any previously undetected small openings. At two other towns, long distance equipment was moved to first and second floor levels, and safeguards for power plants were arranged.

During the years since 1937, the associated Bell companies along the rivers have taken precautions that vary in degree from actually removing central offices from lowland locations to perfecting plans for the rescue of equipment which is to be left in place until the last minute.

Elaborate maps of many riverside exchanges have been prepared, showing in color the areas which will be inundated at any given stage of the river. These maps, plus card systems, enable superintendents and wire chiefs to dispatch plant men systematically to rescue telephone and switchboard equipment as the water rises. The stages of the river might be said to be announced by *Green, Blue,* and *Red* warnings somewhat like the recently abandoned Civilian Defense air-raid alarms.

Also, where equipment must be used in lowland locations the following practices have become standard:

Boat, drums of fuel, and hoisting apparatus on the roof of a telephone building indicate how thoroughly preparations were made for an emergency in the flood zone last March

Cross-connecting and house cable terminals are placed above flood levels on poles and buildings wherever possible. If terminals must be installed where they are likely to be submerged, a sealed chamber is used and the cable run through a cross-connecting box above flood level, so that only the pairs in the sealed terminal will be affected.

Underground cables which are not under continuous gas pressure are equipped with valves so that gas can be fed in if it appears probable that they will be submerged.

When a PBX or key equipment is to be installed, arrangements for protecting the equipment during a flood are discussed with the customer and made certain. Some ingenious schemes have been worked out—such as a block-and-tackle hoist to lift a PBX switchboard through openings in the floors to levels on which it can continue to function during high water, and to lower it again to the location desired by the customer under normal conditions.

Baseboard wiring for buzzer and key systems is not nailed in place, but is fastened with clamps so that it can be swiftly removed.

EMERGENCY STOCKS of many kinds were stored in telephone central offices up and down the river

At Pittsburgh

PITTSBURGH was the first to act on warnings of this year's flood, but the river rose only to a stage of 33.5 feet—not high enough to do much damage. No telephones or bellboxes were lost.

At Pittsburgh and all other river towns, however, it was necessary to marshal defenses on receipt of the warning. That meant checking and building up emergency stocks of repair material, making ready with boats and rubber boots for telephone men, and arranging for stoves, blankets and cots at central offices which might be isolated. Fuel supplies were gathered for emergency power generators and materials were assembled for sandbag barricades to protect cellars and lower-floor openings. The Traffic Departments had to review their plans to make certain of transportation of operators to the offices wherever bus or street railway service might be suspended.

In West Virginia

BELOW Pittsburgh, the Chesapeake and Potomac Telephone Company of West Virginia has 20 central offices serving 66,000 telephones along the Ohio. When a flood occurs, a majority of the people in this area move their furniture above the expected flood stage and remain in their homes. The telephone company in normal times looks after the telephone equipment; and the whole, as may be gathered, is somewhat a routine proceeding.

This year it was necessary to remove or relocate 11 private branch exchanges, 9 key equipments, 23 booths, and 1,538 telephone. About a third of the telephones were saved by customers acting at the request of the company as a war measure. In the over-all job, only 23 telephones and 8 bellboxes were damaged. This compares with a loss of 1,768 telephones and 146 bellboxes in 1937.

In Ohio

No equipment was lost during the 1945 flood in the territory of the Ohio Bell Telephone Company. In the Zanesville district, on the Muskingum river in the upper Ohio valley, subscribers removed 446 telephones at the company's request. Many of these customers said they were pleased to know that service could be maintained until they were forced to vacate.

At Steubenville, Ohio, flood stage is 35 feet. The crest this year was 44.3. The telephone company's pole yard was flooded, but all the poles had been securely lashed, so the only damage was to the driveways, which required 65 tons of slag to make them serviceable again. All told, 176 telephones were removed, most of them in the Follansbee and Weirton steel plants adjacent to the river. Interruption of war work at these plants was a serious matter, and the telephone company made every effort to maintain service till the last minute, and to restore it as soon as possible.

At Bridgeport, 213 telephones were removed. When water blocked the entrance to the telephone office, a fire escape was rigged to a neighboring building whose entrance was dry, and all employees had to enter and leave by that route. Under a bridge adjacent to the office, a jam of driftwood threatened to make trouble, but two experienced rivermen in a rowboat were able to clear it with a boat hook in a few hours.

Marietta, Ohio, greeted the oncoming flood as if it were a county fair. Trucks backed in hub to hub to move out stock from the Front Street stores. No one hurried—they had done this before. But move out they did, and the river took over. Meanwhile, the telephone people began on the river front and worked back up the hill, removing telephones and equipment. All told, the equipment for 826 stations was saved. When PBX boards were taken out or shifted, the cables were cut off and capped. The business office in Marietta was moved to the second floor of a bank building, and the records taken to a central office uptown.

Precautions of another sort: protector installations high on the outside walls of residences, beyond the reach of flood waters

Some lashings gave way in the pole yards, but the loose poles floated into a backwater, where three telephone men had the seafaring job of following them in boats in order to drive a staple into each pole and then anchor it or tie it up.

Soon the river began to recede. Marietta fire hoses flushed away the silt that covered the streets and floors. Truckmen hauled off rubbish and brush piles. And back came the telephones to the water front.

At Ripley, Ohio, further down the river, the central office was moved to high ground shortly after the 1937 flood. It was never in danger this year, although high water covered the business district.

At Cincinnati

The Cincinnati and Suburban Bell Telephone Company reports that while each flood in that city's history added some "know how" to previously accumulated experience, it remained for the 79.9 foot flood of 1937 to become the most effective teacher.

Lessons learned then resulted in rearrangements and improved procedures which were effective against the 69.2 foot flood this year. The company's office at New Richmond, Ohio, which was put out of service during the 1937 flood, has been replaced with a community dial unit located on a hillside well above the 80 foot stage. Old "South" office at Covington, Kentucky, which required sandbag dikes and constant pumping to keep water out of the basement power room in 1937, has been transferred to the Hemlock building, on a high level. Although the power com-

A PUBLIC TELEPHONE is brought to dry land and a longer life of service panies serving the area have improved their plant against flood too, auxiliary power has been installed in all Cincinnati telephone buildings as a further precautionary measure. Wherever possible, customer equipment has been removed to safe locations.

When the Ohio river approaches 60 feet (flood stage, 52 feet) and threatens to go higher, "flood bureaus" are established in the three plant district test centers at Cincinnati, and requests from customers to have telephones removed or moved to other locations are directed by the Traffic Department to these bureaus. When the volume of requests makes it necessary, the bureaus are manned on a 24-hour basis by representatives of the Commercial, Plant and Traffic Departments.

All told, 7,326 telephones were involved in the 1945 flood at Cincinnati. Of these, 945 were moved temporarily to new locations, while 6,381 were taken out pending reestablishment of service after the flood. Of 115 installations involving PBX, TWX, and key cabinet equipment, there was only one recorded loss, and in total about 268 telephones were damaged.

TELEPHONE POLES which broke loose from an inundated pole yard and floated away are towed to a safe harbor

In Kentucky

IN THE Owensboro district of Kentucky, served by the Southern Bell Telephone and Telegraph Company, anti-flood engineering was begun immediately after the waters receded in 1937. All toll lines were raised to levels that would eliminate any possibility of their being submerged or damaged by floating debris. Several magneto offices were converted to community dial and placed above flood level. Eddyville and Maceo are two central offices that were damaged in 1937 which now stand on high ground.

The citizens of Paducah suffered so severely during the flood in 1937 that this year's warnings were received with considerable alarm. This put a heavy burden on the Southern Bell Company's equipment and personnel at a time when service at the highest possible efficiency was required to expedite the work of the emergency committees appointed by city authorities. Furthermore, telephone people themselves were worried for their families and household possessions. Transportation had become a serious problem as one by one the highways out of Paducah became blocked by high water.

A FREQUENT SIGHT along the Ohio River last Spring: temporary removal of equipment ahead of rising waters

A meeting of telephone employees was held at which all available information on the flood was circulated. To those concerned about families and furniture, the company offered its assistance. Since the trucking companies of Paducah were overloaded, arrangements were made for vans from Madisonville to come into Paducah for the purpose of rescuing employees' furniture should necessity arise. It was also arranged to rent Club Lakeview, outside the flood district, to be used as a dormitory for telephone people who might be routed from their homes. A milk company at Mayfield was asked to make ready to supply ten-gallon cans in case it became necessary to haul drinking water. Plans were even made to establish an emergency common-battery office outside the flooded district in the event of a repetition of 1937.

After 1937, however, Paducah had seen to the building of a concrete wall to protect against a 63-foot level. The war had prevented installation of the flood gates in this wall, and of related pumping equipment. The United States Engineer Corps arranged to sandbag the open gates and to borrow pumps from the Tennessee Valley Authority. The pumps cleared low-lying streets of water from blocked sewers and heavy rains. And by regulation of the flow of the Tennessee river at Kentucky Dam, the crest at Paducah was held to 50.5 feet. The sun came out and the crisis passed with muddy water lapping just four and one-half feet below the crown of the sandbag dams in the flood gates.

In Indiana

Along the Indiana side of the river, in the territory of the Indiana Bell Telephone Company, damage to telephone plant was slight, for here again "the levees held." Here, also, customers helped in removal of telephones and bellboxes, so that very little equipment was damaged.

A broken sewer tile let backwater flow into the basement of the old local office building at New Albany, but by constant use of pumps the water was held to a level of four inches, not enough to affect the furnace, cables, or other equipment.

At Evansville, the only other major Indiana exchange threatened by the flood, a crest of 48.3 feet was reached on March 11, as compared with 53.8 feet on January 31, 1937. Every effort was made to remove telephones from homes as rapidly as they were evacuated. To make more certain of the recovery of instruments so vital in wartime, a special line was installed so that the Red Cross office could notify the telephone company whenever it was necessary to evacuate a dwelling. Part of the recovery work was done by combinationmen and linemen in rowboats. They brought in 75 telephones. In all, 250 telephones were moved from flooded areas in Evansville.

In Illinois

Three Illinois Bell exchanges along the Ohio—Cairo, Mounds, and Mound City—were in no danger from the March flood this year. Protected by a sea wall, they are threatened only when the Ohio and Mississippi are both at flood stage.

On a temporary platform raised four feet above the floor, two loyal women maintained service through this switchboard for two weeks while isolated within the office

Emergencies Are Overcome

Each emergency—each upheaval from normal life—means extra work at top speed for the men who install and maintain telephone equipment, and for telephone operators. Sometimes it means work under extremely trying conditions. This year, for example, West Point, Kentucky, between Louisville and Fort Knox, in

Southern Bell territory, was ordered evacuated by the Army Command at Fort Knox, on the afternoon of March 6. The homes of all West Point operators—five in number—were flooded.

But although the water was still rising and the telephone office was completely surrounded, the night operator got a rowboat and returned to the office of her own accord on March 7. She restored toll service, and local service on the 15 lines still working. Two days later the chief operator was able to return to the office in an Army amphibious vehicle, and a little later two other operators joined them.

Fort Knox itself was teeming with activity all this while. With the military personnel confined to the post, and with a large population of evacuees in addition, the switchboard and the attended pay stations were swamped with calls.

At Louisville, many operators had to move to temporary quarters because of flooded basements at home or because water in the streets made their homes inaccessible. They remained on duty, however, and some took advantage of the living arrangements provided at the telephone offices by the Southern Bell Telephone Company. When the high schools of Louisville were dismissed at 11 a. m., March 6, nearly all of the 90 high-school girls who were working part time for the telephone company reported for duty. Many former operators also offered their services.

Many thousands of telephones were saved from damage by being removed from structures in the high-water area and stored in safety until the flood receded

At both the Louisville and Paducah long distance and local boards, calls came too rapidly to be counted during the crest periods. At Jeffersonville, Indiana, at times 90 per cent of the switchboard lamps appeared to be lighted. At New Albany, long distance calls were twice those of a normal wartime day.

At Grandview, some 32 miles up the river from Evansville, Indiana, water rose to within inches of the floor of the telephone exchange. The wire chief and combinationman, with the advice and assistance of the Evansville district plant superintendent, constructed a seven-by-nine-foot platform on saw horses 50 inches above the floor. They put the switchboard on the platform and also contrived to place a cot beside it.

From this lofty perch, the agent and her operator handled Grandview's telephone calls for two weeks. They could not set foot outside the office, and were dependent on the men for food, coal, and other necessities brought by boat from Rockport, five miles away.

While these are possibly the most newsworthy incidents reported in connection with this year's flood-time telephone service, the fact must not be overlooked that tremendous traffic and urgent situations had to be dealt with from Pittsburgh to Cairo.

OPPORTUNITY was taken to recondition key cabinets and PBX switchboards while they were out of service

THIS YEAR's highly successful countering of a great Ohio flood had importance beyond the intrinsic value of equipment saved and loss prevented, for in wartime such home front victories aid the smooth supply of armies at the front. As in every telephone achievement, two factors were involved. One was the Bell System's willingness to learn lessons and plan ever more thoroughly to circumvent emergencies. The other was the unfailing response to public need that is characteristic of telephone people on the job. The coming of the flood found the supervisory groups better prepared than they ever had been before. And it found the telephone men and women of the Ohio Valley exchanges ready as always to make any necessary personal sacrifice to get the message through.

Singing Wires

When winter is about ready to abdicate to spring, and the pussy willows lift their branches, comes the time when the telephone wires along the winding back-country roads sing their arias of a new season. Singing wires are a part of the music in the air when spring is ready to ascend her throne.

There is undoubtedly a learned scientific reason why telephone wires put on their orchestral performance. This is a scientific age and we cannot expect even a free symphony to occur without good reason. Perhaps the best performances of the year are given in late March. On a mellow day when the south wind is blowing, when the sky is wearing its cape of deepest blue, with a few masses of white cumulus clouds for ruffles, the wires seem to enjoy their steady song.

The song of the wires is steady but it is not monotonous. There are overtones of lyrical runs, long sustained notes in alto and contralto key, deeper intermittent overtones of resonant bass. Occasionally one gets a faint hint of a clean, haunting pure high tenor. There are times when the tempo mounts in crescendo fortissimo; one almost expects the crash of the percussion instruments and the stirring lifting power of the brasses. Then, again, the wires sing softly of day's loveliness, humming a theme of unexplored possibilities, sustaining the music to accompany the rollicking optimism of robins.

There are men and women in city offices who will look out their windows these hope-stirring days and think of country roads far away where the telephone wires run from weathered pole to pole, above the lichened stone walls or split rail fences. Years ago they listened to the singing wires. Boys and girls coming home from schoolhouses with lunch boxes in hand still stop to listen. In the song of wires in spring, youth has heard the call to paths of adventure.

From The New York Times, *by permission*

me XXIV • Number Two Summer 1945

Bell Telephone MAGAZINE

Electrical Communications in World-wide Warfare:
On the Ground • In the Air • At Sea

Operator Toll Dialing—A New Long Distance Method
James J. Pilliod and Harold L. Ryan

The West Coast in the War • George H. Jess

erican Telephone & Telegraph Company · New York

Bell Telephone *Magazine*

Summer 1945

EDITORS' NOTE: Two of the three articles listed below deal with communications at war. As these pages go to press, there are indications that the surrender of Japan is imminent, and therefore this issue may be distributed in a world at peace. If that should happily be so, the articles will perhaps have no less interest as a record of some of the ways in which communications have contributed to the victory.

Electrical Communications in World-wide Warfare:
On the Ground—In the Air—At Sea, 54

Operator Toll Dialing—A New Long Distance Method,
James J. Pilliod and *Harold L. Ryan,* 101

The West Coast in the War, *George H. Jess,* 116

Who's Who & What's What in This Issue, 131

A Medium of Suggestion & a Record of Progress

Published for the supervisory forces of the Bell System by the Information Department of
AMERICAN TELEPHONE AND TELEGRAPH CO., *195 Broadway, New York 7, N. Y.*
WALTER S. GIFFORD, *President;* ROBERT H. STRAHAN, *Secretary;* DONALD R. BELCHER, *Treasurer*

Electrical Communications in World-wide Warfare

Major General Harry C. Ingles

I. *On the Ground*

By Major General Harry C. Ingles

CHIEF SIGNAL OFFICER, UNITED STATES ARMY

ALL AMERICANS are overjoyed at the glorious victories won in Europe by the forces of the United Nations. Hundreds of officers participated in planning the crucial battles of the final campaign against Germany. These battles were led by thousands and fought by millions, but they were directed by one man—the Supreme Commander—who dealt with the destinies of nations and the lives of countless human beings.

Vital to victory was the prompt and certain transmittal of battle orders from the highest echelon down through the chain of command to corps, to divisions, and thence to smaller units, and the immediate translation of those orders into coördinated action.

The instrument by which coördination was achieved is military communication. It is the responsibility of the Signal Corps to supply the Army with a system of communications which radiates from the War Department in Washington to every spot where American troops are in action. It is a system which shapes the pattern of our armies' movement and striking power, serves every commander and every soldier, and holds them together in united action.

In fashioning this vast network and in manning and producing its equipment, the Signal Corps has had the unstinted support of the entire electronics industry and the commercial communications companies. These organizations have placed the war needs of the Nation above all other considerations. Their response to all military demands has been prompt and patriotic. By their unselfish public service they have earned the lasting gratitude of the country.

It is my confident conviction that this splendid coöperation will continue not only until Japan has been defeated but far into the coming years of peace.

The Main Channels of Military Communication

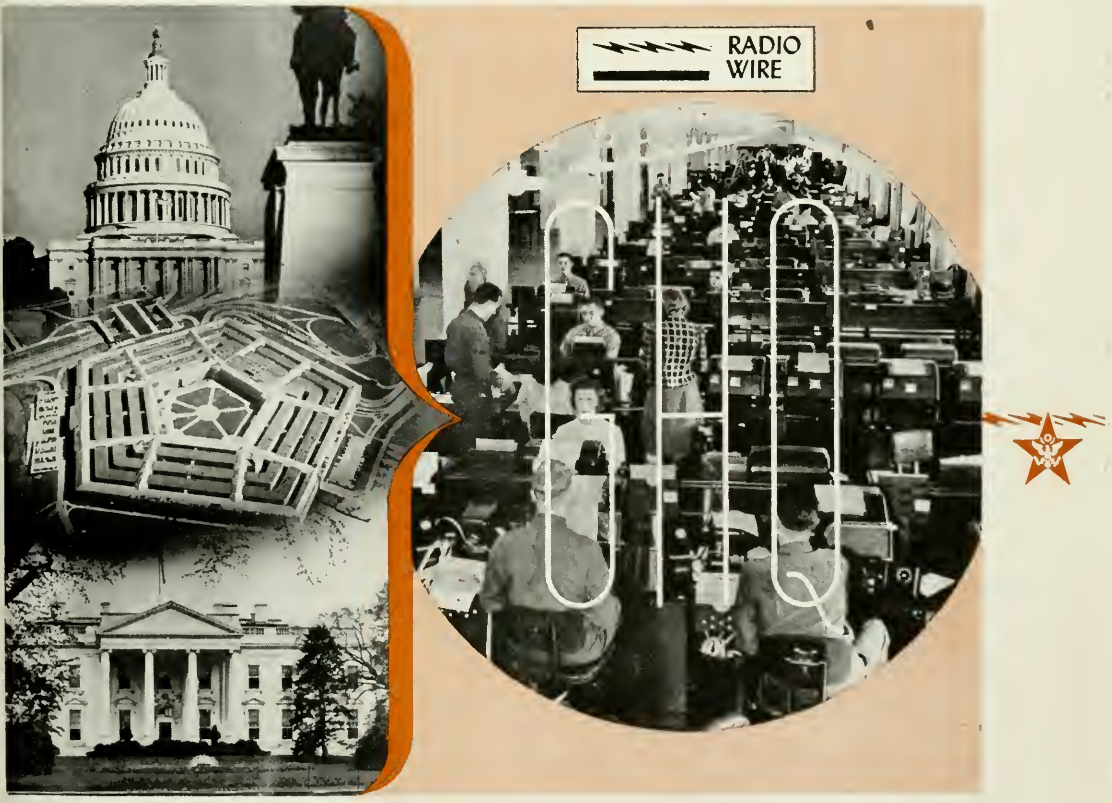
Out of this nation's prosecution of global war has come in a few swift years a military communications system unparalleled in history. On every continent and across every ocean it carries messages at incredible speed and in incalculable number.

Many men are needed to install and maintain and operate this globe-encircling system. There are more men in the Army Signal Corps today than in the entire U. S. Army of six years ago, and the communications specialists in other branches add many thousands more to the total.

The Signal Corps catalog of equipment lists more than 100,000 separate items, of which about 1,000 are of major importance. The quantities in which they are made and used are best expressed not in numbers but in thousands of tons.

This communications system exists for but one purpose: to unify into a single organism the staffs at Washington and in the theaters of operation, armies, corps, divisions, regiments, battalions, companies, platoons, patrols—integrating them with one another and with the grand plan of global strategy.

The system's vastness and complexity are beyond description. But it is possible—by over-simplifying, by narrowing down, by eliminating the intricate secondary and lateral lines interconnecting all branches and



services—to represent graphically the main channels of military communication. On the lower halves of these dozen pages are shown an "ideal" arrangement of wire and radio circuits, typical to greater or less degree of any theater in which American troops are engaged, over which messages may pass "from Pentagon to foxhole."

The photographs on the upper halves of these 12 pages illustrate the military importance of electrical communications of many kinds and in many fields of combat

Soldiers and civilian personnel operate these teletypewriters at an overseas headquarters

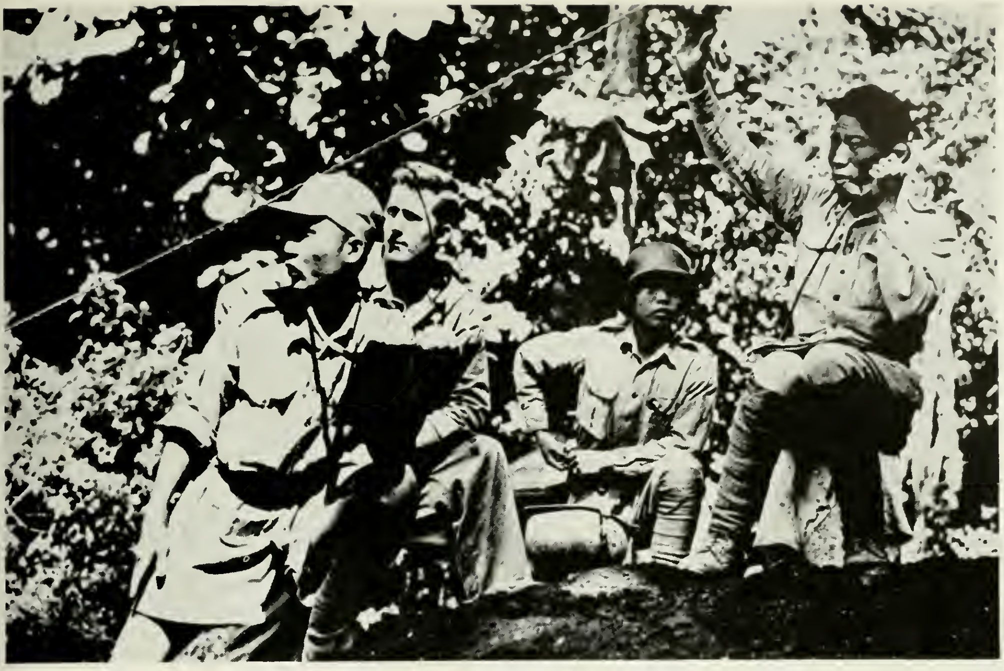
A TELEPHONE POLE left standing near Manila by the Japs comes down to repair a bridge which they demolished

BATTLE-TORN Manila's communications are revived as U. S. Signal Corps troops restore telephone cable

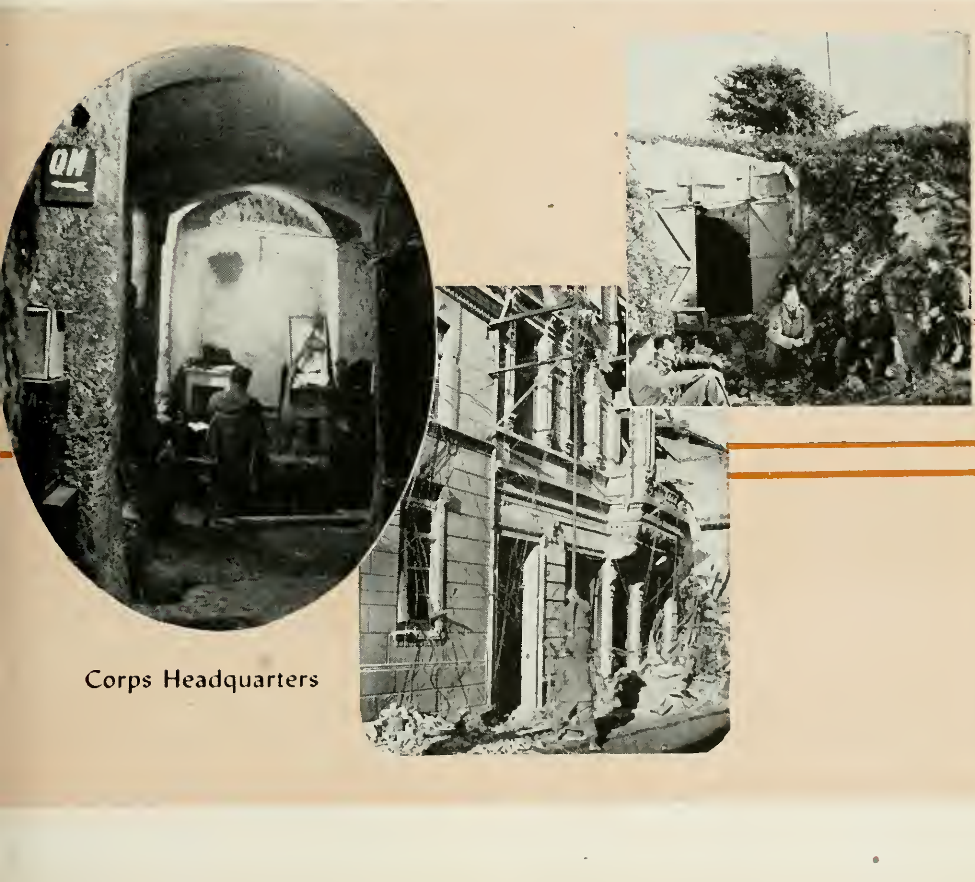
Army Group Headquarters

TELEPHONE WIRE must penetrate dense tropic jungles, as here on Bougainville, where trees serve the moment's need as telephone poles

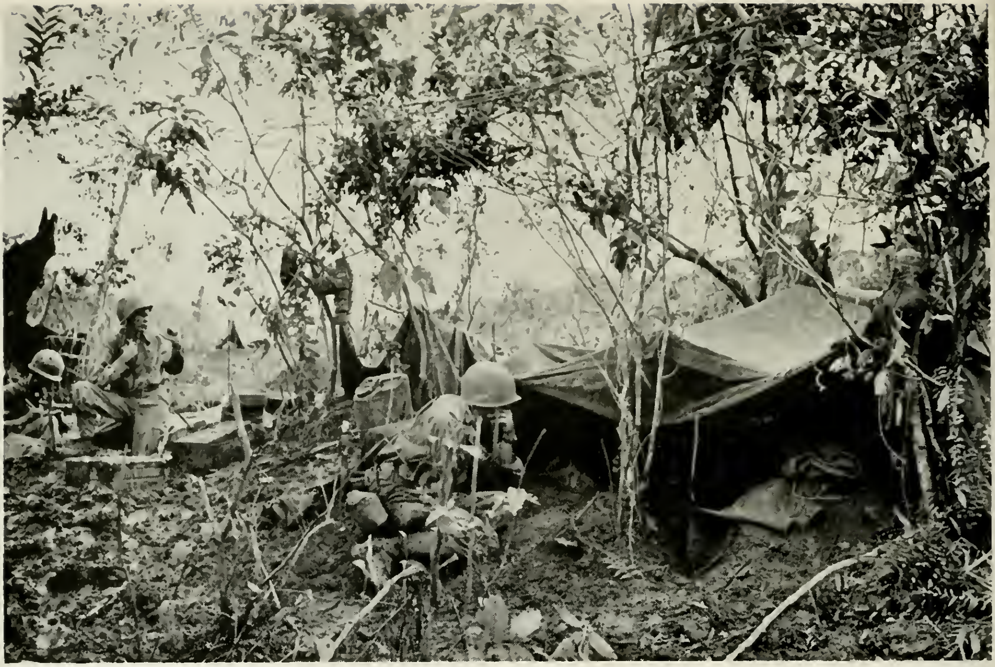
Army Headquarters



In the China-Burma-India theater, an American officer and Chinese troops observe the effect of artillery fire against the Japanese

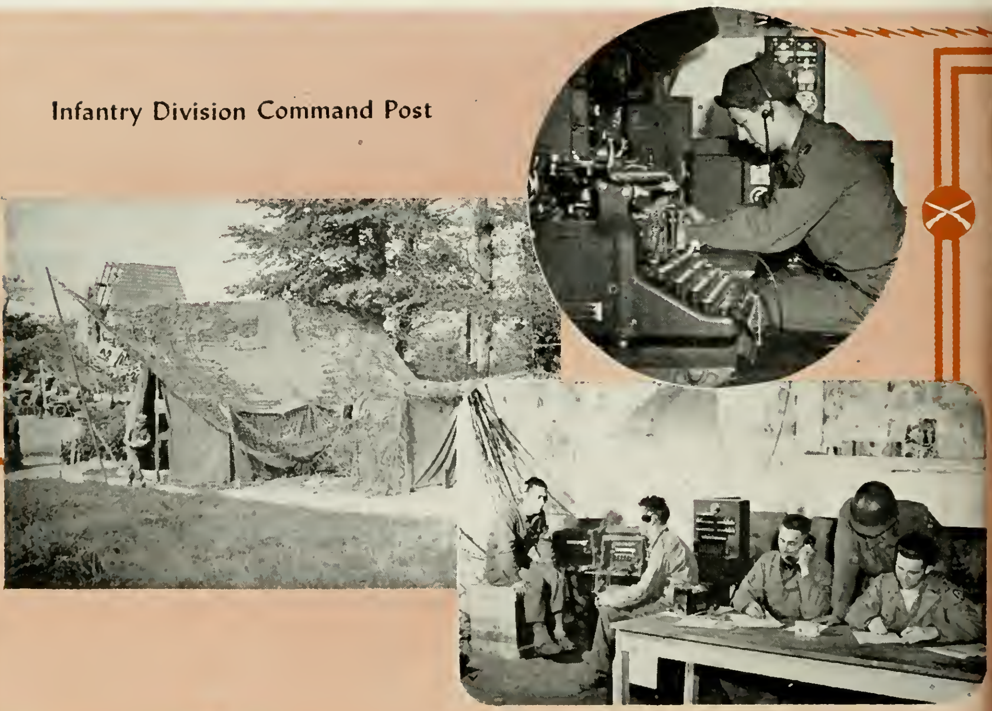


Corps Headquarters



THIS forward command post overlooks Lemon Valley on Leyte Island in the Philippines

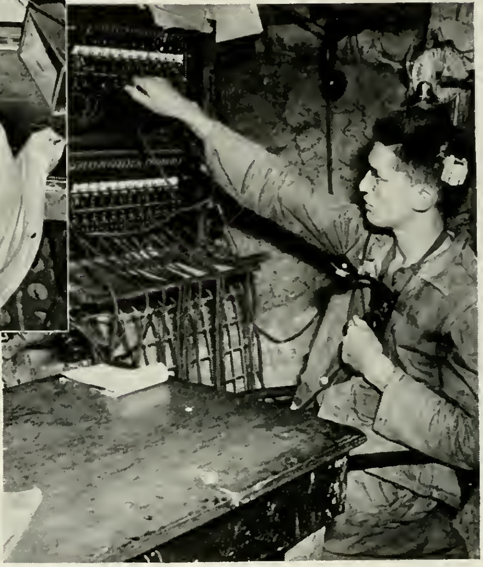
Infantry Division Command Post



ONE UNIT of a gun director. Telephone communication between directors and artillery batteries is of prime importance

Armored Forces Division Command Post

LEFT: Receiving a message in a radio hut on a Pacific island



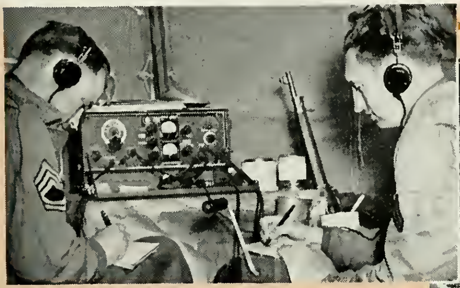
RIGHT: Switchboards in a communications dugout in the Pacific theater

Infantry Regiment Command Post

Armored Forces Combat Command Post

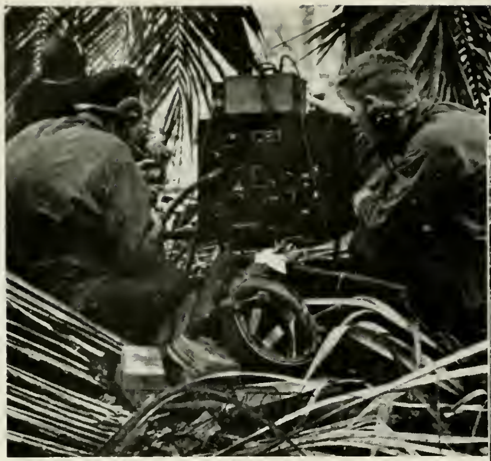
Divisional Artillery Command Pos

A COMMAND POST message center in Hollandia



Infantry Battalion Command Post

Artillery
Battalion
Command
Post



THIS radio set was brought ashore and put into operation during a landing on Butaritari Island

IN A dugout shelter in New Guinea these Signal Corps men test telephone circuits with others who are outside "shooting trouble"

Infantry Company Command Post

Armored Battalion Command Post

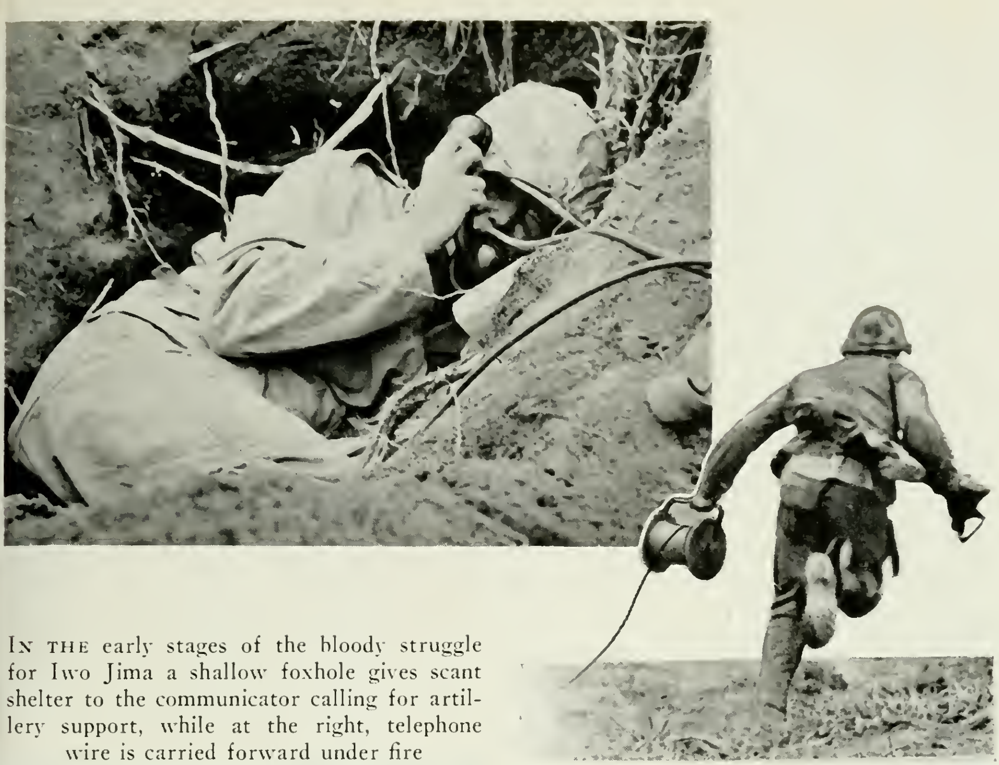
Behind the wreckage of a Japanese plane, Americans direct artillery fire from a shell-hole command post on Iwo Jima

Artillery
Battery
Commander
and Gun Crew

Tank Company Commander

THE telephone switchboard makes this cave the nerve center of Vella Lavella Island

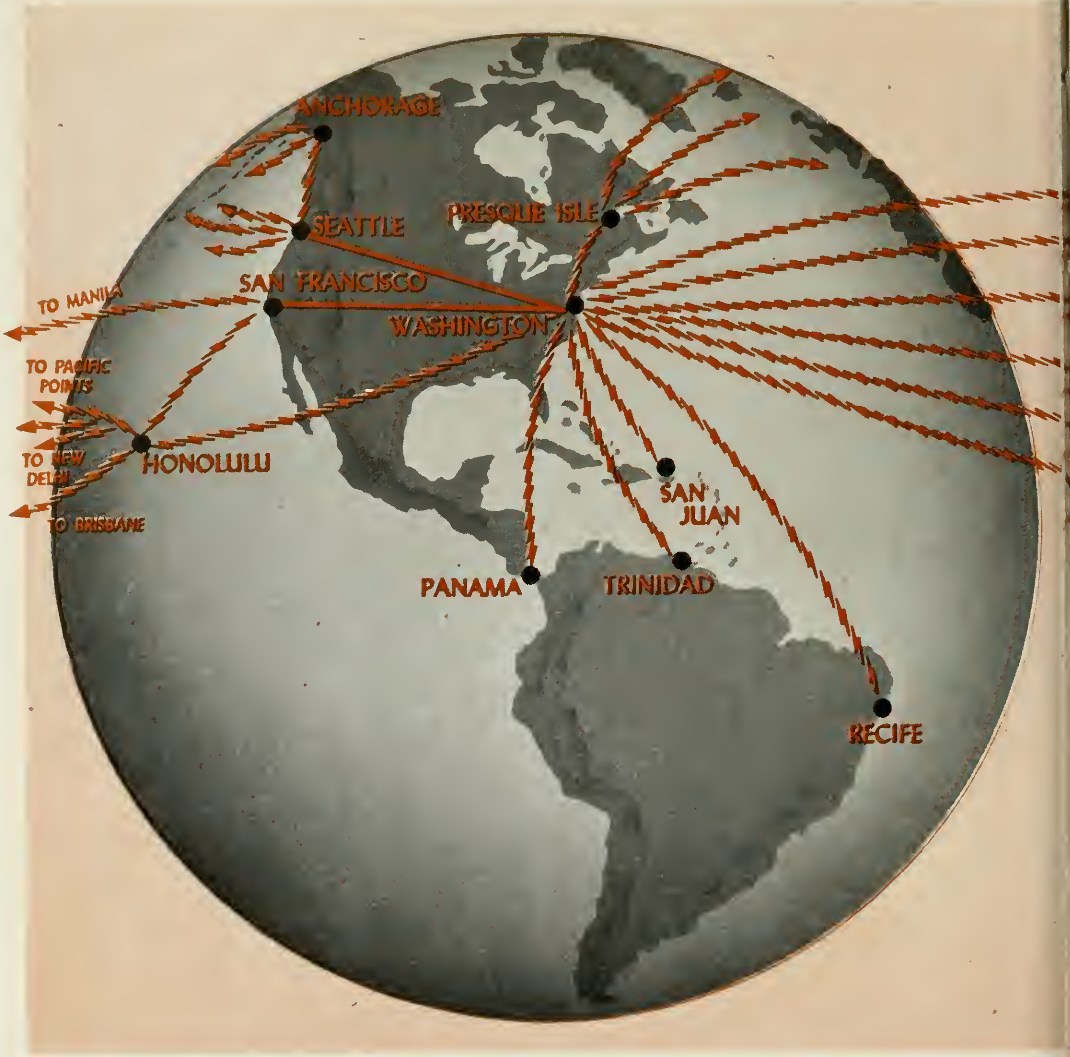
Artillery Observation



In the early stages of the bloody struggle for Iwo Jima a shallow foxhole gives scant shelter to the communicator calling for artillery support, while at the right, telephone wire is carried forward under fire

Infantry – the Front Line

Tanks in Action

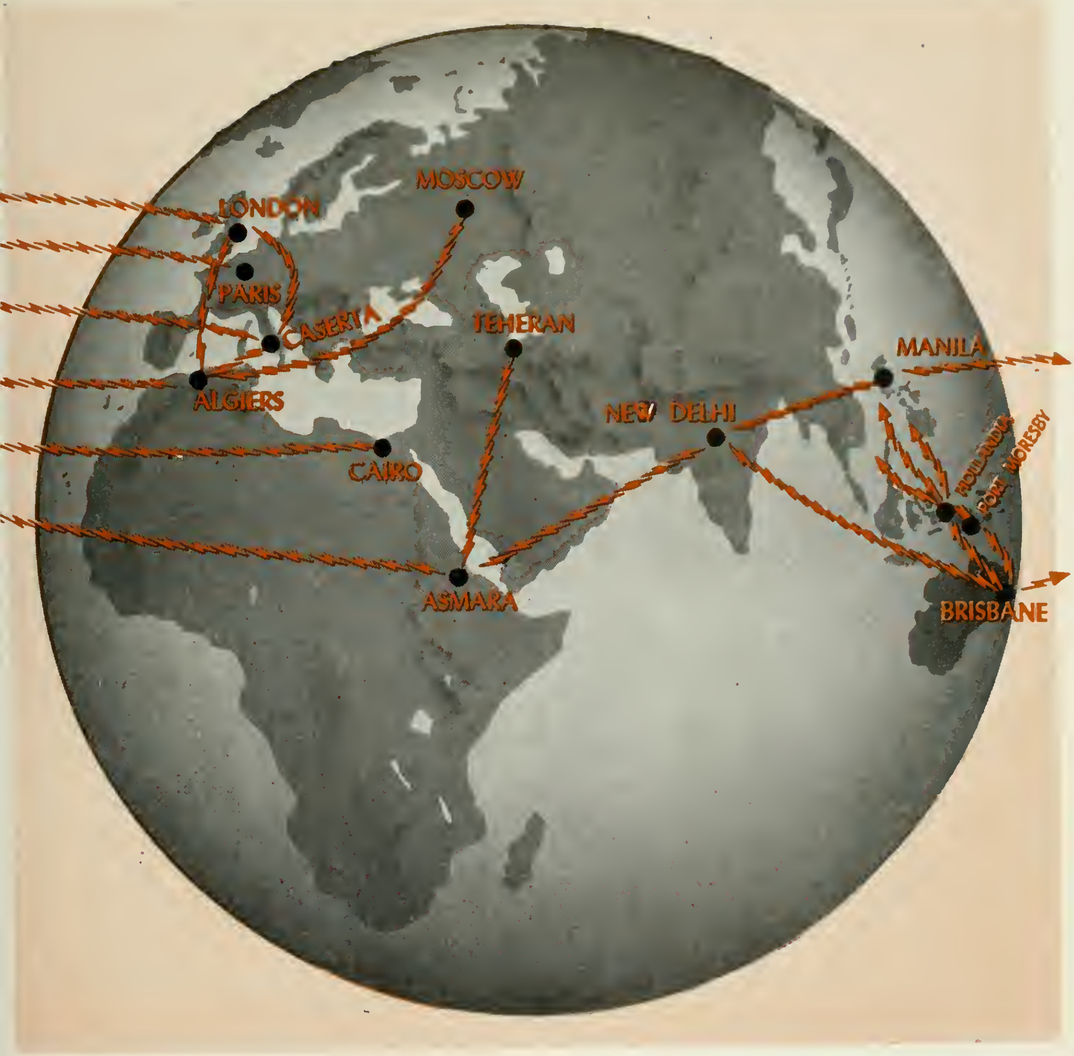


The Army Command and Administrative Network

The perfect control and coördination of all military elements of this Nation's fighting forces on far-flung battle fronts is a vital factor in achieving victory.

The War Department communications networks, through which this control and coördination are accomplished, cover the United States by wire, and spread out by radio to the headquarters of all overseas theaters of operations, making connections there with many other smaller networks which may reach into every tank, plane, and lonely outpost.

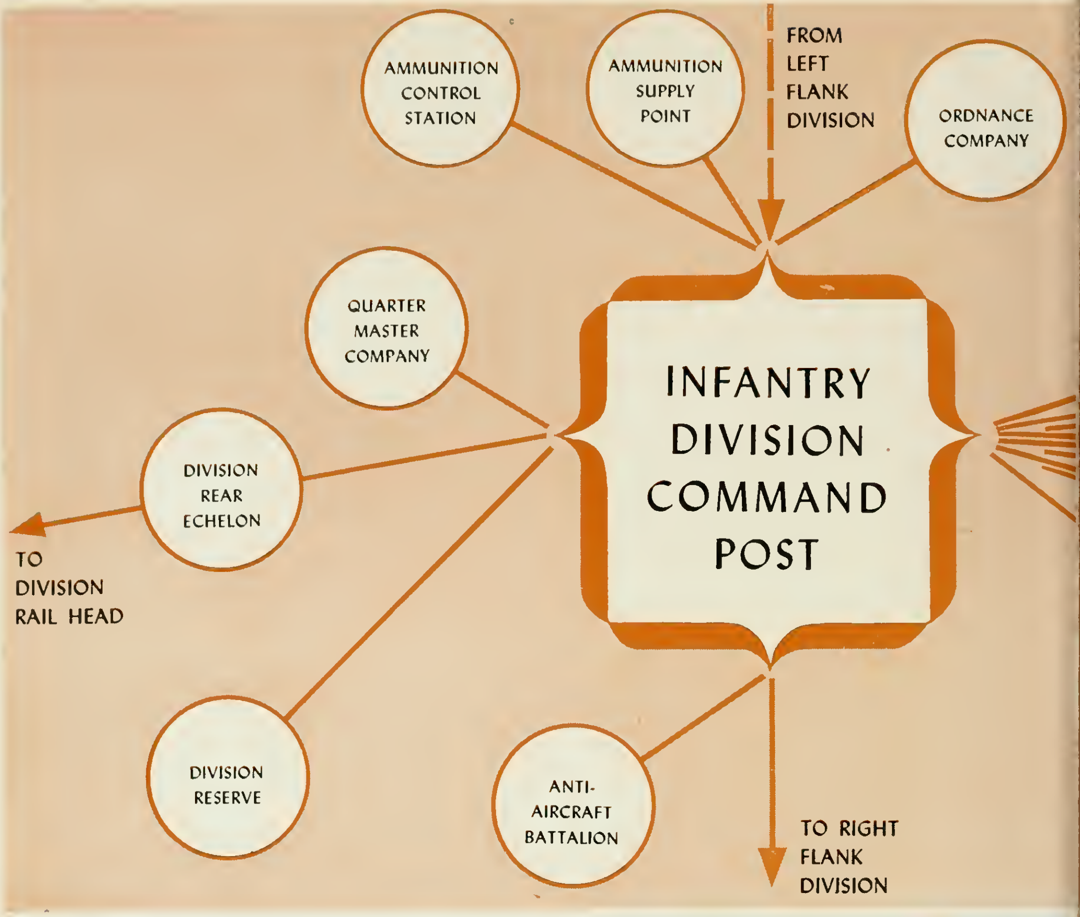
The backbone of this gigantic system is the Army Command and Administrative Network, installed, operated, and main-



tained by the Army Communications Service of the Signal Corps. More than 50,000,000 words per day have flashed over its circuits—tremendous volumes of highly important military and diplomatic traffic on which may depend the success or failure of the war, the lives and welfare of the soldiers, the very security of our country.

The Nation's inventive genius, engineering skill, and electrical resources were pooled in the creation of this integrated world-wide system. Possibly the most significant single development was the placing of communications on virtually an automatic basis, eliminating the old dot-dash method of transmission. Messages converted into strips of perforated teletypewriter tape may be relayed swiftly and efficiently from land line to radio and back to land line. Recently, in a demonstration of flexibility, Army Communications Service sent a nine-word message completely around the earth, through four automatic relay stations, in 9½ seconds.

On these two pages are shown the principal radioteletypewriter circuits which make it possible for the high command in Washington to maintain immediate and intimate contact with all overseas commanders.



How War Consumes Telephone Wire

A TYPICAL infantry division's normal supply of telephone wire when it goes into combat exceeds 700 miles.

Wire must move with the troops. Often there is not time to recover it after a position has been held for a period. So a fresh supply of wire is needed for each move.

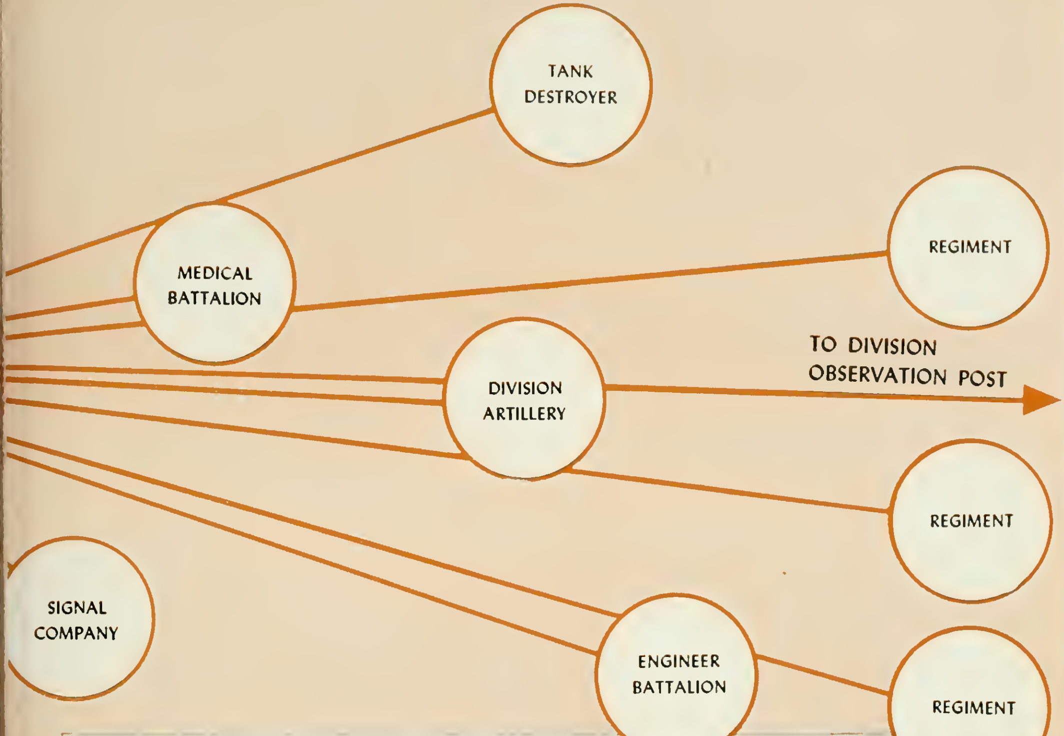
And while a division is in position, the enemy tries by every means possible to disrupt and damage its communication lines. Many miles of wire are lost to such action, and cannot be re-used.

As soon as an infantry division command post is established, one or more wire circuits fan out as quickly as possible to the units listed on the opposite page.

The majority of these channels are trunk circuits terminating in switchboards from which there may be from four to forty extensions. An infantry division, including the usually attached units, has about 70 switchboards which serve more than 550 field telephones.

There are still further ramifications. From division artillery, for instance, two lines must go to each of its four field division artillery battalions. In turn, each battalion must have wire communication with its three gun batteries, and with forward observers, and with infantry regiments.

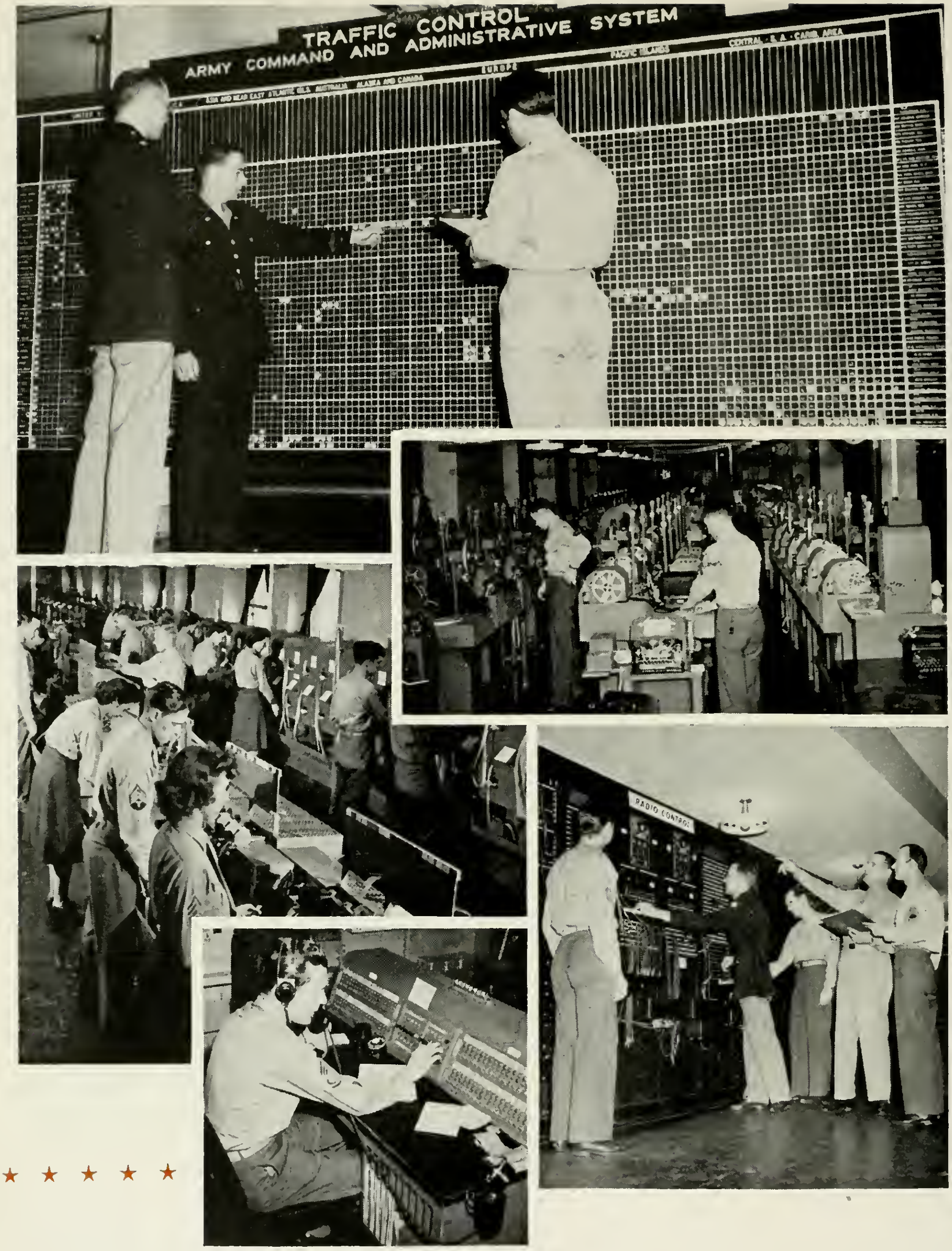
THAT is the average wire requirement of a single infantry division. Thought of in terms of all divisions, of all arms, of all theaters, it gives some understanding of how war consumes telephone wire.



COMMUNICATIONS MATERIÉL at an overseas supply depot

From An Infantry Division Command Post, Wires Run To—

Each of three infantry regiments, distance 5 to 20 miles each
Division artillery, distance 2 to 15 miles
Division observation post, distance 5 to 20 miles
Engineer battalion, distance 5 to 20 miles
Ammunition control station, distance 5 to 15 miles
Division reserve, distance 5 to 15 miles
Right flank division, distance 1½ to 4 miles
Rear echelon, distance 5 to 40 miles
Through rear echelon to railhead, distance 5 to 20 miles
Quartermaster company—Signal company—Ordnance company—Medical battalion—Traffic control stations
Attached tank destroyer battalion, distance 5 to 20 miles
Attached anti-aircraft battalion, distance 5 to 15 miles
Other attached units



★ ★ ★ ★ ★

Station WAR

THE War Department Signal Center is the key station in Army Communications Service's world-wide system. More than 9,000,000 words of war flow daily through this ultra-modern center, connected by wire with military installations throughout the United States, and by radio—through giant remotely-controlled transmitters and receivers—with all overseas theaters of operations. Shown here is some of the equipment which permits the speedy and efficient handling of so great a volume of messages.

★ ★ ★ ★ ★ ★ ★

★ ★ ★ ★ ★ ★ ★

Major General Harold M. McClelland

II. *In the Air*

By Major General Harold M. McClelland

CHIEF AIR COMMUNICATIONS OFFICER, HEADQUARTERS
ARMY AIR FORCES

Development of the many types of Army Air Forces communications facilities, embracing radar, radio, telephone, and teletypewriter, has been a vital factor in the development of our air superiority.

From the beginning of the war, air communications have been called upon more and more to perform such vital tasks as guiding our aircraft to their targets, identifying those targets, locating enemy planes, and supplying our aircraft with the proper navigational aids to make safe returns to their home bases. Exploration of all the ways of accomplishing many seemingly impossible tasks has, in a few short years, developed an air communications system unequalled by any other military power.

The vast communications facilities of the Army Air Forces encircle the world. If they were visible, they would appear as a great web around the earth. Through this system, operational, tactical, and administrative information is sent and received by our innumerable fighting units.

There are more than twenty pieces of communications and electronic equipment in a single heavy bomber. With the employment of special devices, our forces are capable of seeing the enemy at night or through clouds, and are able to identify bombing targets even in the worst weather conditions. Through the use of this and other early warning equipment, our forces are alerted to the opposed planes and ships. This integrated communications system also distributes weather information urgently needed for the planning of all air operations.

In the Army Air Forces more than 400,000 of the Army's personnel are required for the operation, supply, maintenance, training, procurement, and storage of this communications equipment. The magnificent skill, effort, and loyalty of these men and women are attested by the flight of every plane that cleaves the air and by the achievements of the AAF in every theater.

★ ★

Army Air Forces Communications

Essential to the operations of the Army Air Forces are electrical communications: in the air, on the ground, and between ground and air. While it is unlikely that all the actions depicted below would ever take place within view of a single observer, the composite sketch illustrates in small compass the uses of many of the important systems of communications and items of equipment which contribute to the military success of the AAF. Among them are:—

Instrument approach system for aircraft

Air-sea rescue communications, for the rescue of flyers forced down at sea

Communications and radio navigation for airborne landings

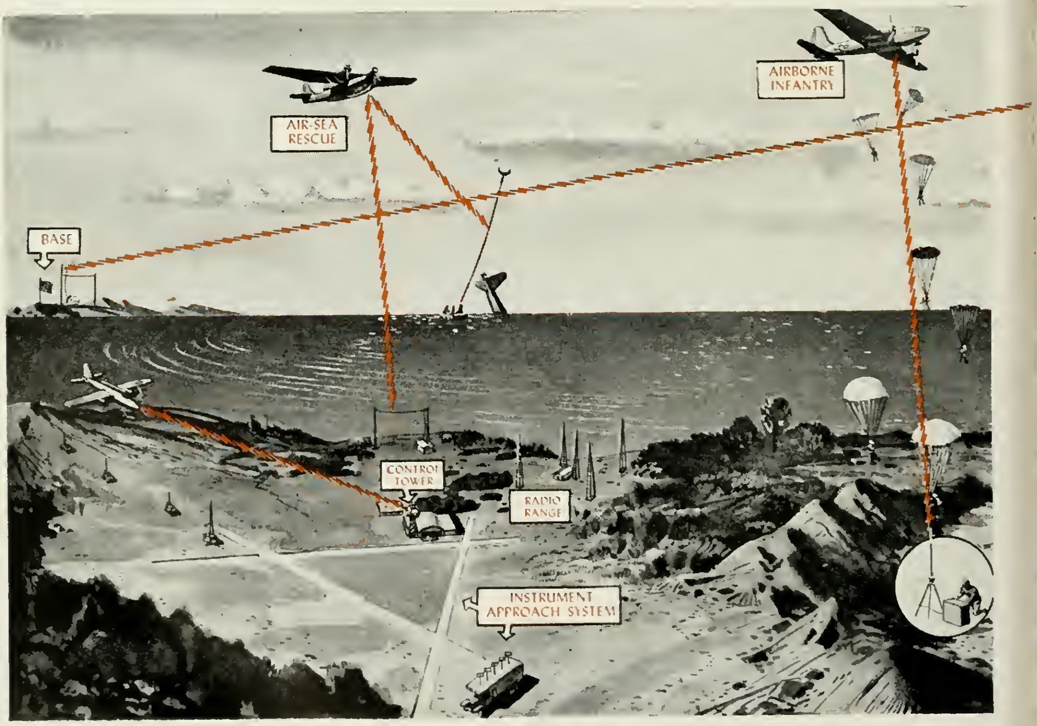
Strategic bombing communications with bomber base and with protecting fighter escort

Tactical bombing of and firing on enemy forces

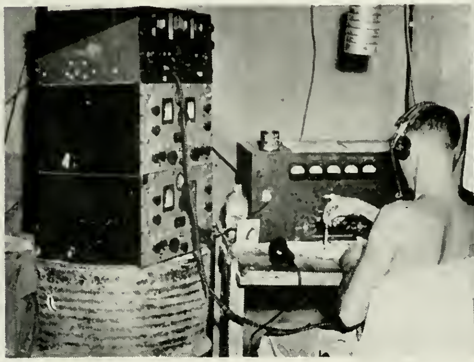
Control by radio communications of fighters against enemy aircraft

Long-range radio navigation system for the use of aircraft flying great distances

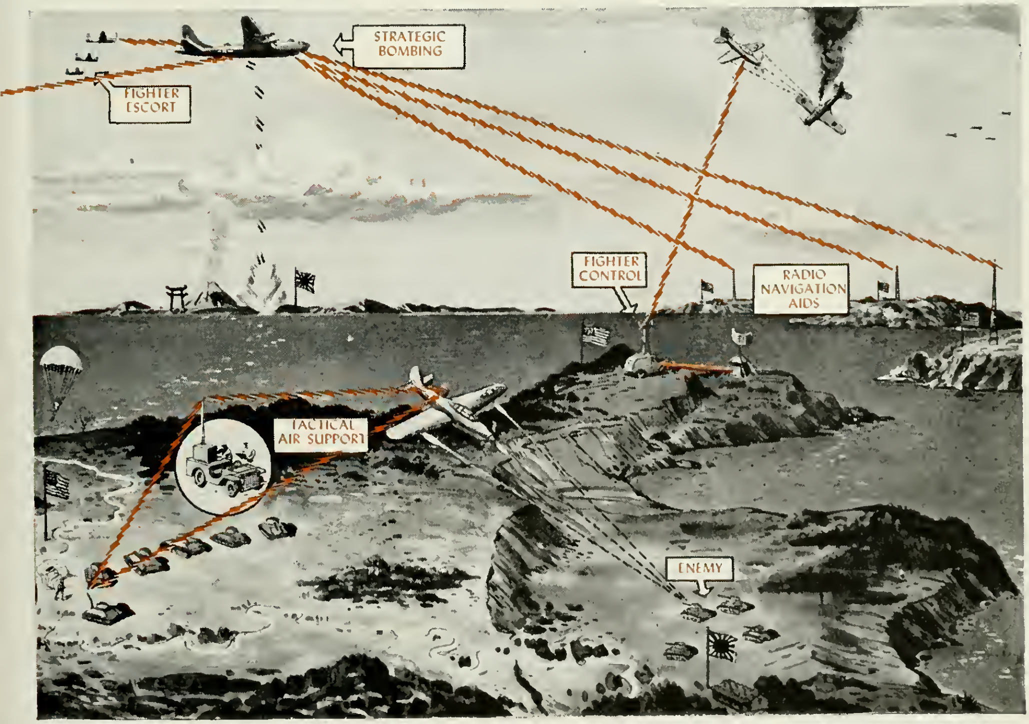
Above: Coördination of air and ground forces at the front is often accomplished by such small units as this



THE radio operator of an Army transport plane maintains the all-important link with the ground stations



ABOVE: Make-shift facilities have been used to set up radio communication quickly at many a newly won airstrip. Right: An air coöperation installation such as this provides weather information and directs air support during an advance



Army Airways Communications System: Nerve System of the AAF

The U. S. Army Air Forces—among other jobs—operate the world's largest air transport system. To guide the planes on their courses and maintain constant contact with them, radio highways in the sky stretch over the earth, along all the military air routes, and right up to the battle fronts. This globe-encircling network is operated by the Army Airways Communications System.

Many thousands of men, scattered in 1,000 small detachments throughout 48 states and 55 foreign countries, operating millions of dollars' worth of radio, telephone, and teletypewriter equipment, are required to perform this immense task.

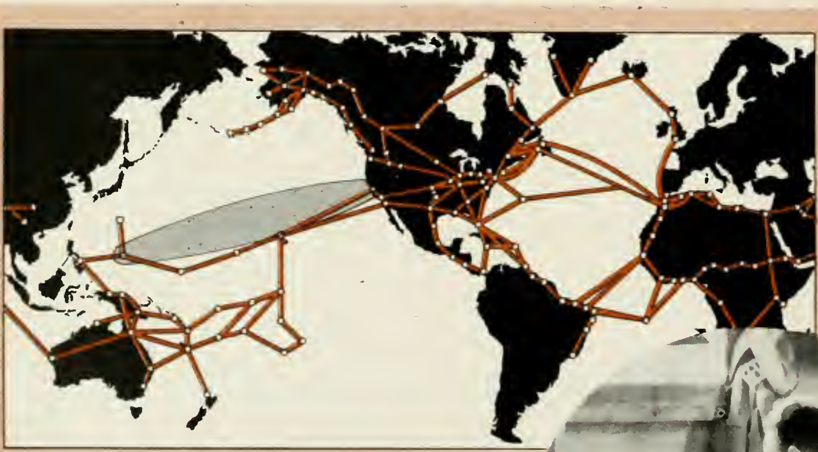
Messages concerning aircraft movements are flashed from airbase to airbase, never permitting a plane to come in "unannounced."

AACS point-to-point stations transmit weather information with the speed of light from the far reaches of Greenland or the south Pacific to the stations that information affects.

Position reports, radioed to AACS ground stations by airborne operators, are quickly relayed to the ship's home base, where a constant chart is kept on the plane's progress.

Hundreds of radio ranges, commonly called "beams," and homing beacons and other electronic navigational aids dot the globe, guiding AAF airplanes through fair weather and foul.

AACS men sit out their lonely vigils in



It's 5,000 miles from San Francisco to Saipan.

Requisitions for planes and crews are filed to the United States from a Pacific base over the operational and administrative point-to-point circuits of AACS.

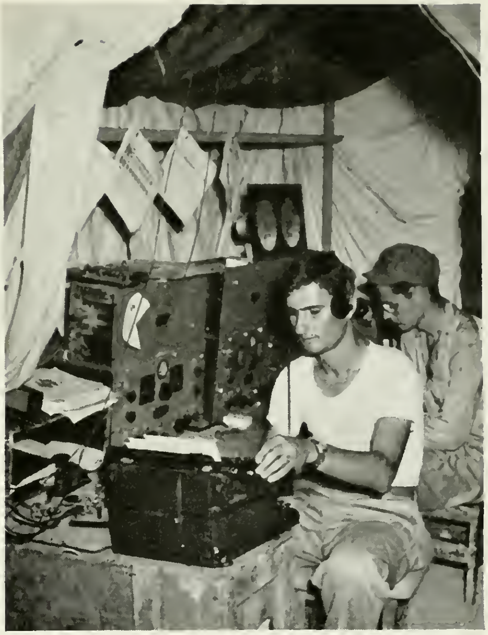
direction-finding stations scattered in remote areas, not only to plot the position of some lost plane but to keep hourly check on flights over spots once regarded as the most difficult to navigate.

Instrument-landing crews constantly adjust their equipment and silently "sweat it out" as a plane breaks through the overcast over the runway, guided to earth by the radio paths transmitted by their equipment.

The men of the Army Airways Communications System have rewarding knowledge of airplanes and crews saved by their communications facilities, as well as of the routine and uneventful flights which build up such staggering figures as these:—

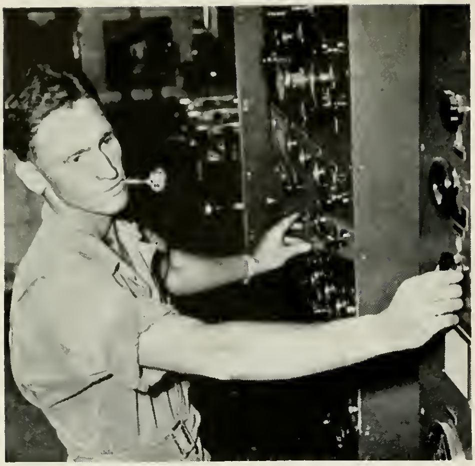
Every 15 minutes a military plane takes off for a flight across the Pacific. Every 13 minutes one takes the air to cross the Atlantic. Every 2½ minutes, during peak traffic periods, a cargo plane crosses the fabulous "Hump."

If all the radio navigational aids operated by AACS were placed equidistant around the 25,000-mile girdle of the equa-



In lonely stations such as this in the China-Burma-India theater, AACS men keep their vigils the world around

Weather reports come from Baffin Bay, Dayton, Attu, Hawaii, Iwo Jima, and many another distant point over AACS circuits for the pilot's information as he plans his flight.



An AACS maintenance chief checks radio transmitters at a busy communications center

tor, they would constitute a continuous radio highway with a radio range or homing beacon every 80 miles.

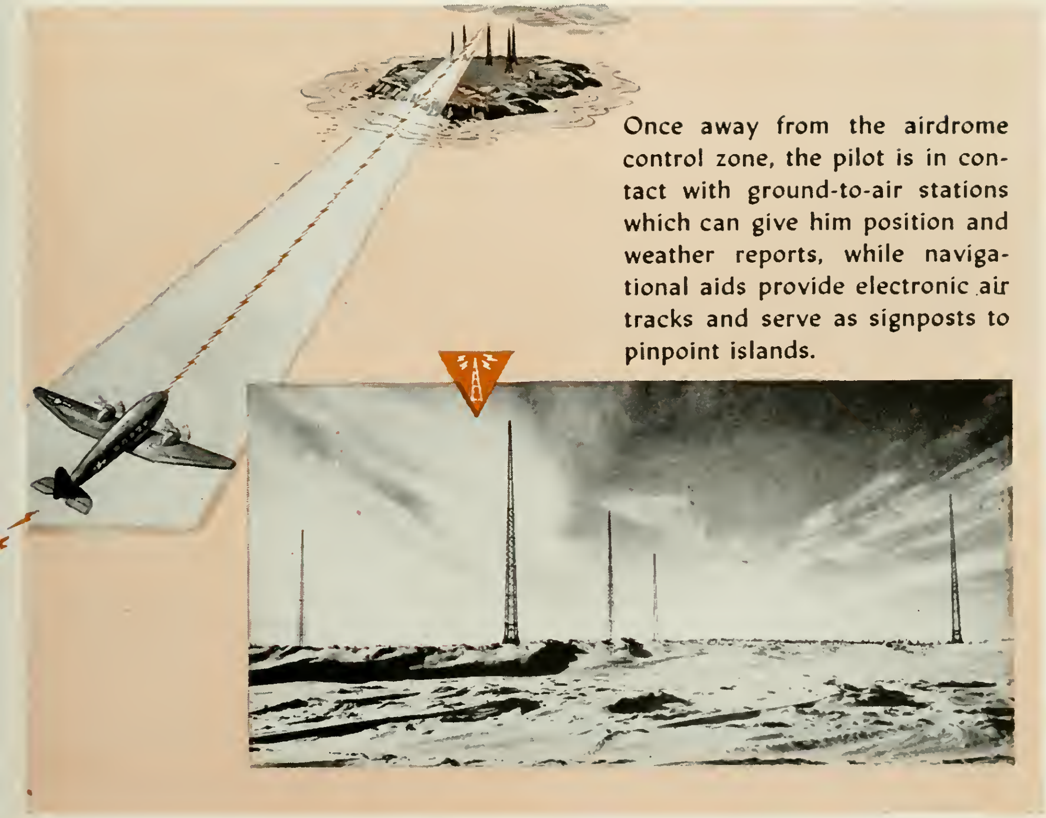
Other statistics are equally impressive. More than 300,000,000 words a month are transmitted by point-to-point stations. Ground stations make more than 50,000 "contacts" with planes in flight each day, and control tower operators, controlling landings and take-offs at air bases from Iwo Jima to Paris, made more than 4,000,000 "contacts" a month.

The prime function of the Army Airways Communications System lies in the provision of necessary radio facilities to guide aircraft along military air routes. But it is not all uneventful. Operating "JACSPAC," the joint communications system for the Army and Navy in the Pacific, AACS detachments have put equipment on beachheads while shells and mortar fire picked at the ground. During dozens of consecutive amphibious operations in the Southwest Pacific, AACS men have moved in under fire.

In the battle of the Pacific, with its long supply lines and watery air routes, it would be difficult to over-estimate the importance of the part played by the communications facilities provided by the Army Airways Communications System, "the nerve system of the AAF."

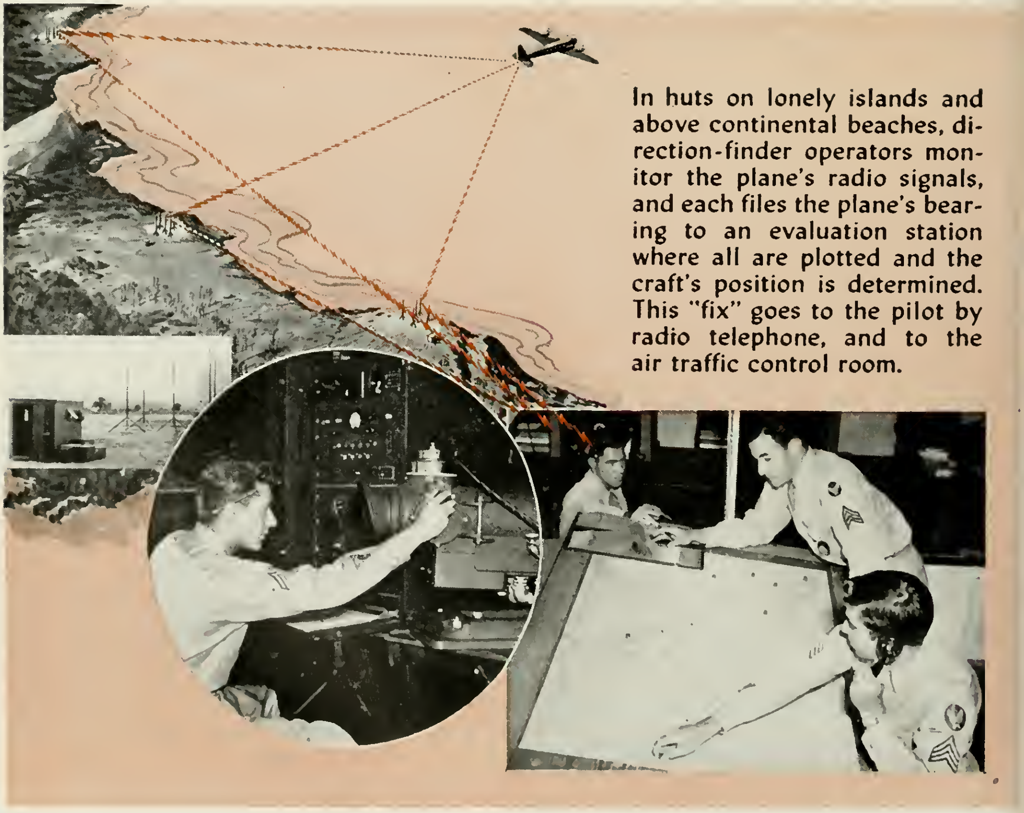
Communicating with the pilot by radio telephone, AACS control tower operators at busy AAF air terminals around the world direct the landing and take-off of all planes.

An air-borne radio operator keeps in touch with AACS ground stations to receive weather information and report the plane's position



Once away from the airdrome control zone, the pilot is in contact with ground-to-air stations which can give him position and weather reports, while navigational aids provide electronic air tracks and serve as signposts to pinpoint islands.

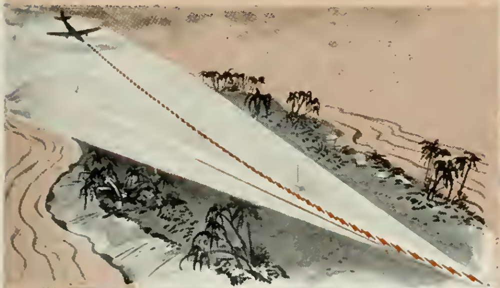
From this "elevated foxhole" on top of Saipan control tower the men controlled the take-offs and landings of B–29s while under Japanese fire



In huts on lonely islands and above continental beaches, direction-finder operators monitor the plane's radio signals, and each files the plane's bearing to an evaluation station where all are plotted and the craft's position is determined. This "fix" goes to the pilot by radio telephone, and to the air traffic control room.

FROM Burma to the United States, the men at the AACS control towers do their important jobs under all sorts of conditions

One of the latest electronic aids to air navigation, the instrument landing approach system guides the pilot "downstairs" through "weather" along a straight obstruction-free path of descent to the point of landing.

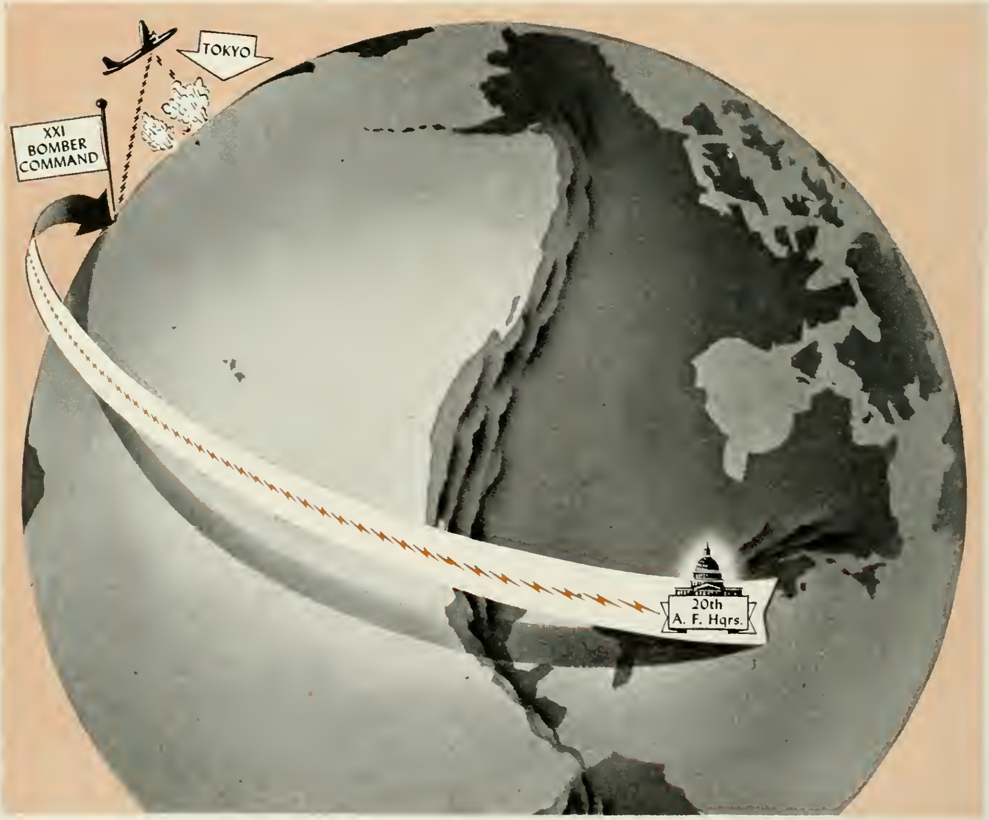


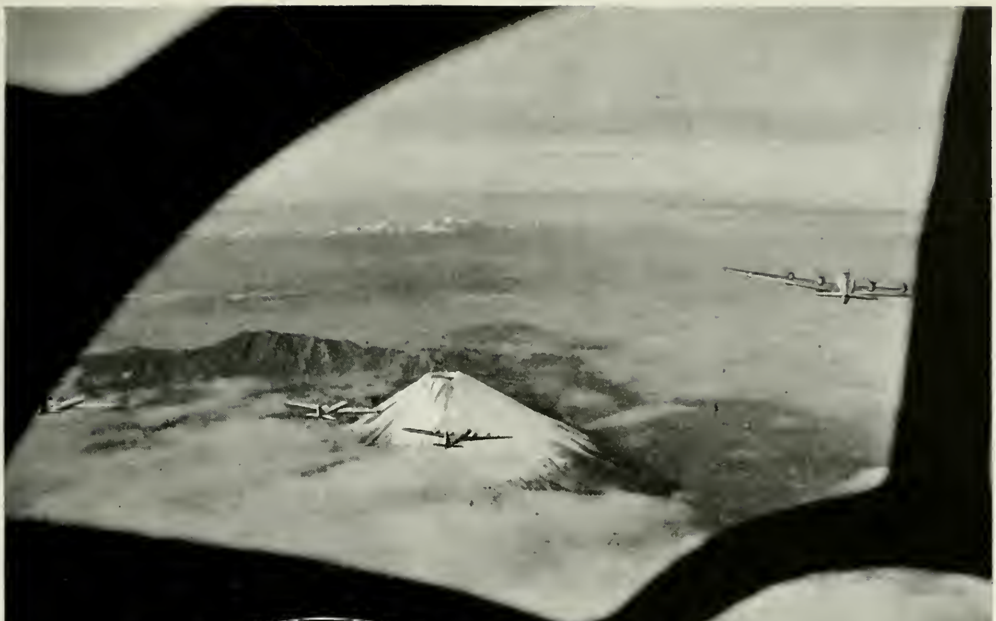
At the end of the flight, as at its start, the AACS control tower operator gives the pilot necessary information: correct order of landing, wind direction and velocity, and other facts needed for the safe completion of the trip. As the plane's wheels touch the ground, the tower operator reports "time of landing" to air traffic control.

Twentieth Air Force Communications

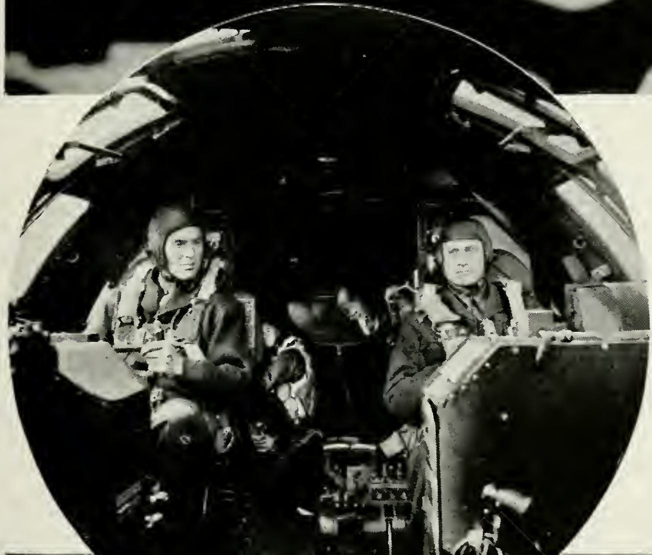
When the bombardier of a B-29 releases his bombs over Tokyo, this fact may be known at the Headquarters of the Twentieth Air Force in Washington within four minutes—so swift and so direct is the communication between the planes of that strategic air force and the staff group which directs its operations across a distance of 9,000 miles. Organized as a strategic air force operating on a global scale, with its central headquarters in Washington, the Twentieth Air Force has developed its radio communications system to cover vast distances at high speed: point-to-point from Washington to the headquarters of the XX and XXI Bomber Commands in Asia and the Pacific; and air-ground between the bases and the B-29s—which fly the greatest ranges of any combat aircraft yet developed. Through these communications facilities, it is actually possible for Twentieth Air Force Headquarters to extend control of operations to B-29s in flight upon their mission of destruction against the enemy.

The stinger in the tail of a B–29



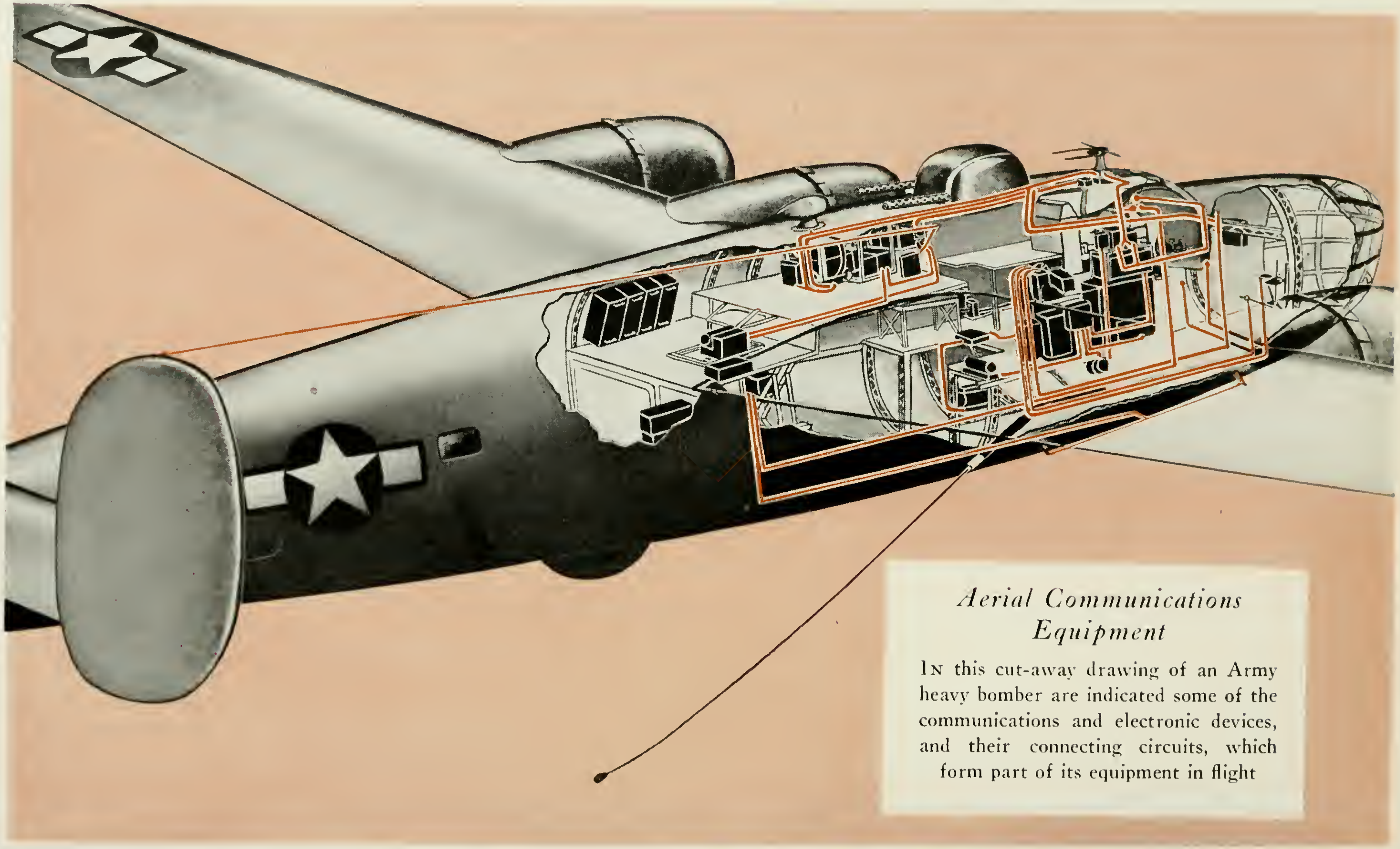


B–29s over Japan. Taken from the nose of a Superfortress on their first bombing raid over Tokyo, this picture shows the cone of Mount Fujiyama dead ahead



WITH pilot and co-pilot of this B–29 in their seats, the flight engineer, navigator, and radio operator are taking their places in the cabin

SUPERFORTRESSES of the 20th Air Force fly high and far above the clouds



Aerial Communications Equipment

In this cut-away drawing of an Army heavy bomber are indicated some of the communications and electronic devices, and their connecting circuits, which form part of its equipment in flight

Rear Admiral
Joseph R. Redman

III. *At Sea*

By Rear Admiral Joseph R. Redman, USN

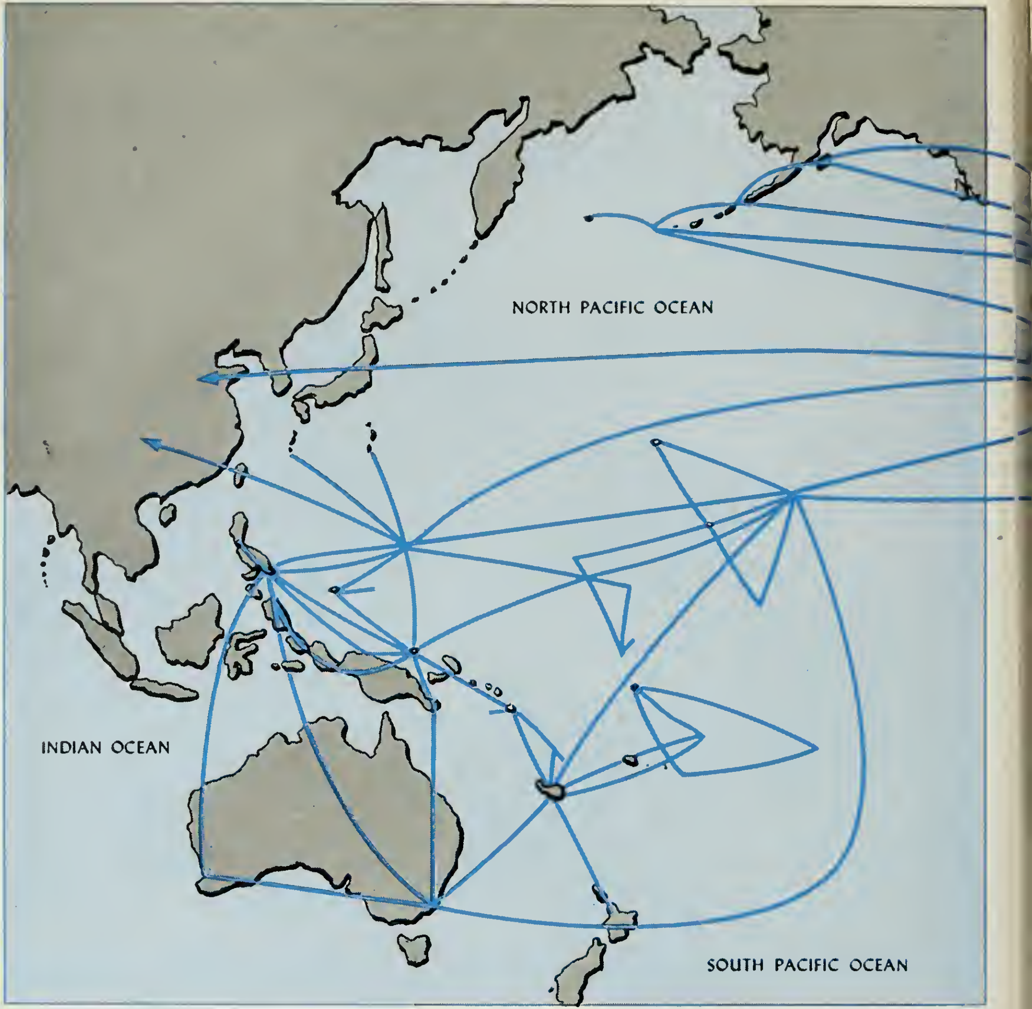
DIRECTOR, NAVAL COMMUNICATIONS

In the Navy we have a particular need for a reliable, efficient, and lightning-fast system of communications, because our fighting units are ever mobile and must be capable of operating on all seas, however remote. That is why radio is such a vital factor in our communications, and why the Navy has played such an important part in pioneering and development in this field.

Between Naval shore stations and elements of the fleet, radio messages are transmitted which concern such vital matters as grand strategy and such important but routine affairs as supplies and personnel. By radio, an admiral has control of the disposition and tactics of the units of his fleet at all times. Between ships, when radio silence is not imposed, flash communications of many kinds. Carriers and their planes maintain contact by radio. Success of an amphibious operation, that most hazardous of undertakings, is dependent upon the coordination of action of hundreds of vessels, obtained largely by radio. And, once the beach-head has been won, radio provides the link between the invading forces and the supporting elements off shore. Due to the speed with which modern naval combat units operate, both in the air and on the surface, there is such a heavy demand for radio channels in mobile operations that top priority in the use of radio spectrum space is required. It is natural that this speed-up of mobile operations will carry over into post-war commercial activities when similar spectrum priority will be needed.

Proportionately, voice communication by wire telephone is less used; yet every vessel has its own system or systems of vital interior communication, ranging from elaborate dial installations to sound-powered telephones.

All these modern, highly developed methods of communication contributed much to the Navy's share in the defeat of Germany; and across the long reaches of the Pacific their part in the coming victory over Japan will be impossible to over-estimate.



MAJOR POINT-TO-POINT CIRCUITS OF

Fundamentals of Naval Communications

THE KEYNOTE of naval warfare is movement. Naval communications must be able to reach any point on the surface of the earth where ships or planes may go, and must be able to do so at all times without prior notice.

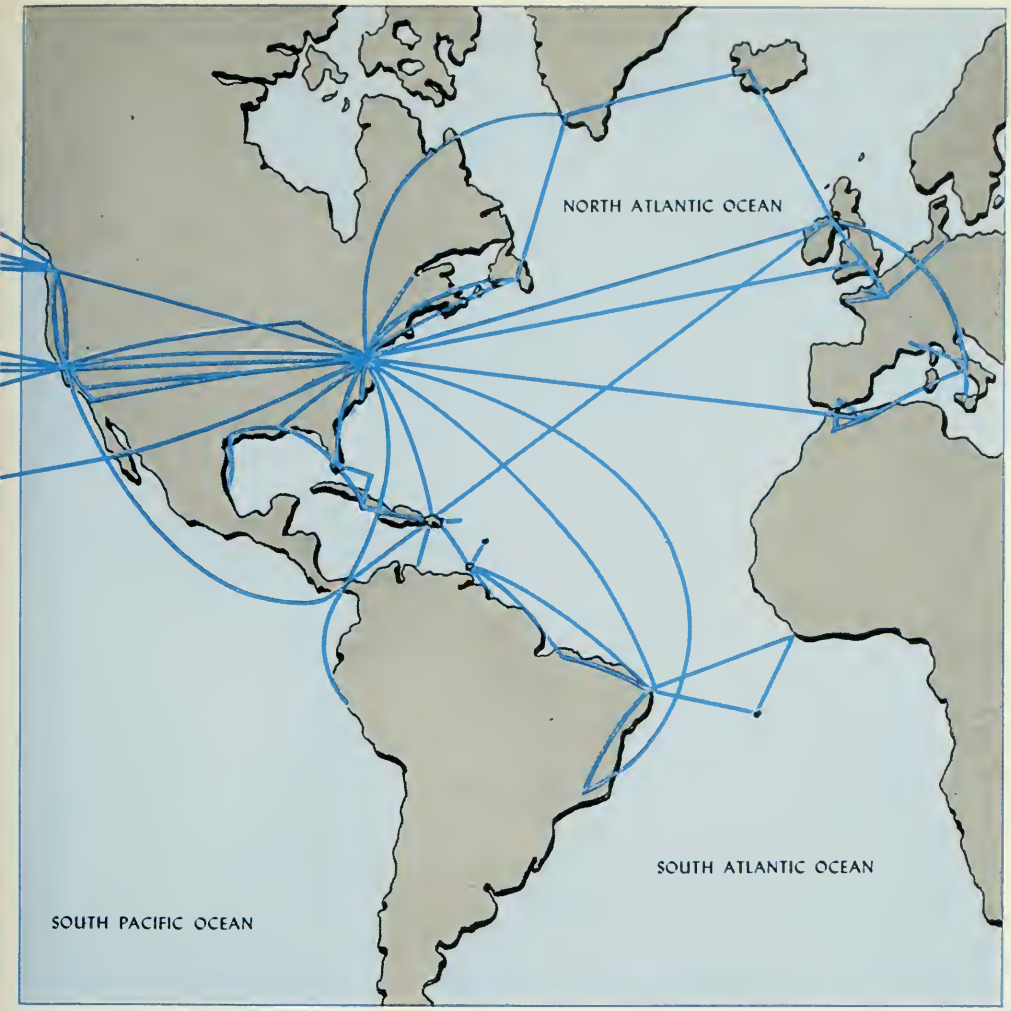
The solution of this problem, complicated enough, is made infinitely more difficult by the necessity to conceal the location of the point where the message is received. Apparatus to detect the location of radio receivers has reached a high degree of excellence and counter-measures must be equally good.

The entire naval organization has one purpose: to support the fleet. The requirements of the fleet govern the entire set-up of Naval communications, the design of equipment, the uses to which it is put, and the location of communication centers.

In so far as is possible, land wires are used in continental regions.

Full advantage is taken of multiple-channel improvements as these are developed. Both ashore and afloat, teletypewriter instruments are used whenever possible, and their numbers are increasing rapidly.

Advanced communications bases are



THE NAVAL COMMUNICATIONS SYSTEM

placed where needed to facilitate transmission to the fleet, wherever it may be operating. The need for such bases sometimes is unforeseen, due to the mobility of naval warfare, and often they have to be established at short notice.

The speed of communications has increased considerably since the war began. Research has produced numerous new means of electronic communications and has found new uses for methods already in existence. These are, of course, highly secret for so long as they may be of use to an enemy, but the entire world will benefit after the war by some of the developments introduced in Naval communications to meet the needs of the service.

These new means of communications have had a direct effect on the conduct of the war. To a considerable extent, it is due to them that task forces and fleets have been able to operate at sea for longer periods and at greater distances from bases than had been possible, or than is possible now for the enemy. No longer must the U. S. Navy strike and then return to base.

As the chart shows, the communications center of the Pacific at present is Guam. Besides the official messages transmitted over regular service channels, the news of the Pacific war reaches the people of the United States through that island. Four voice circuits are open to the press between Guam and the United States, and the messages sent over them are repeated by teletypewriter to insure accuracy.

LEFT: Instant telephone and radio communication is essential to the Navy's dramatic air-sea rescue operations

BELOW: Part of the radio transmitting installation on Guam, headquarters of Naval operations in the Pacific

Stations Ashore

IN THE European phase of the war there were existing cables, wires, and radio installations which might be utilized; but in the Pacific, most of the communication bases have had to be built from the ground up.

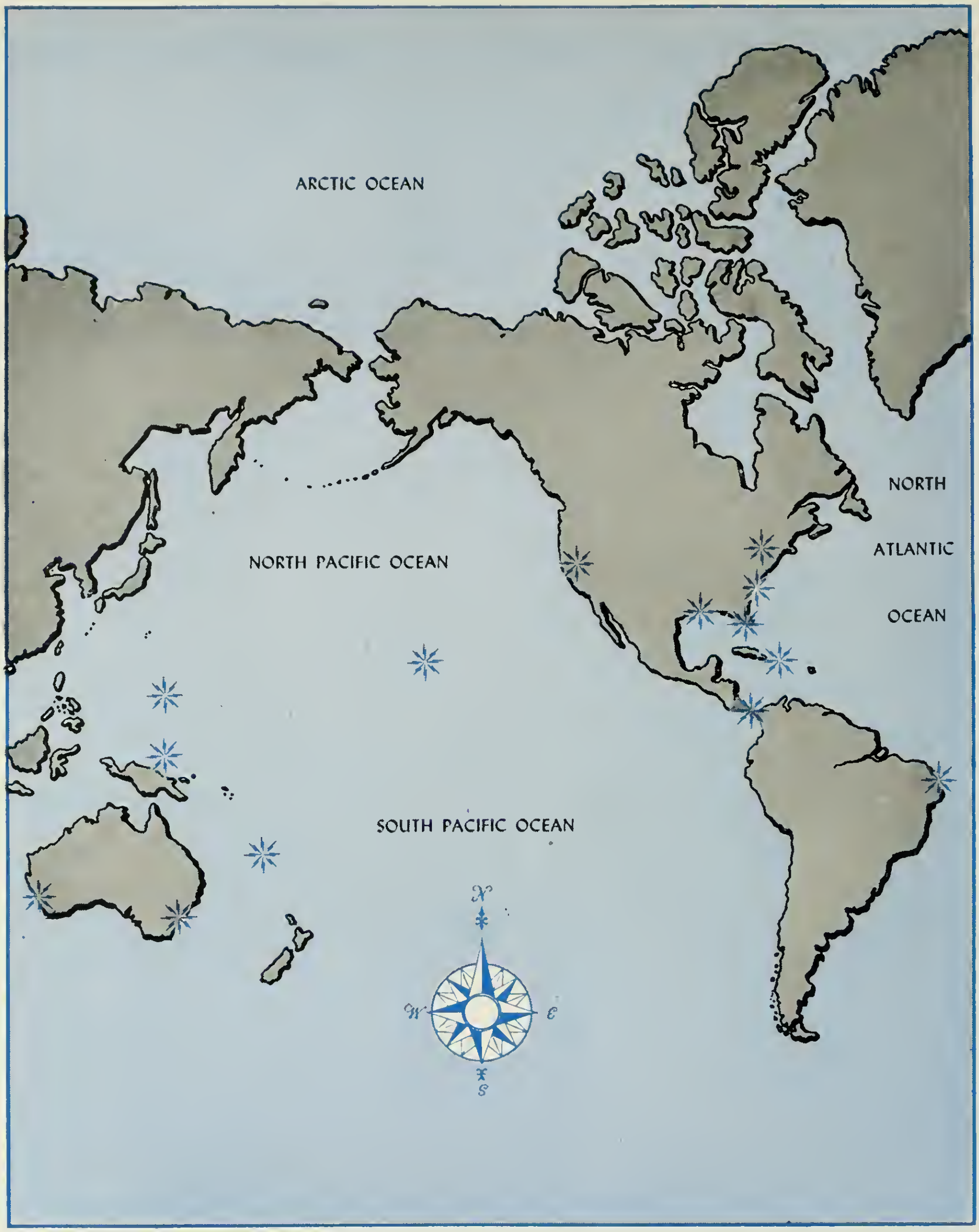
Naval communications men, working above and below ground from New Zealand to Alaska, have built a chain of stations which now approaches Japan itself.

These are the links between the fighting men and the people at home.

Electrical communications save Navy outposts from complete isolation in the bleak Alaskan winter

A radio installation is erected in a jungle clearing on a Pacific island

A signalman (left) strings telephone wire in the Pacific; and (below) Marines operate radio equipment in a communications office of a Marine Air Group



NAVY RADIO BROADCASTING STATIONS

For Silent Ships

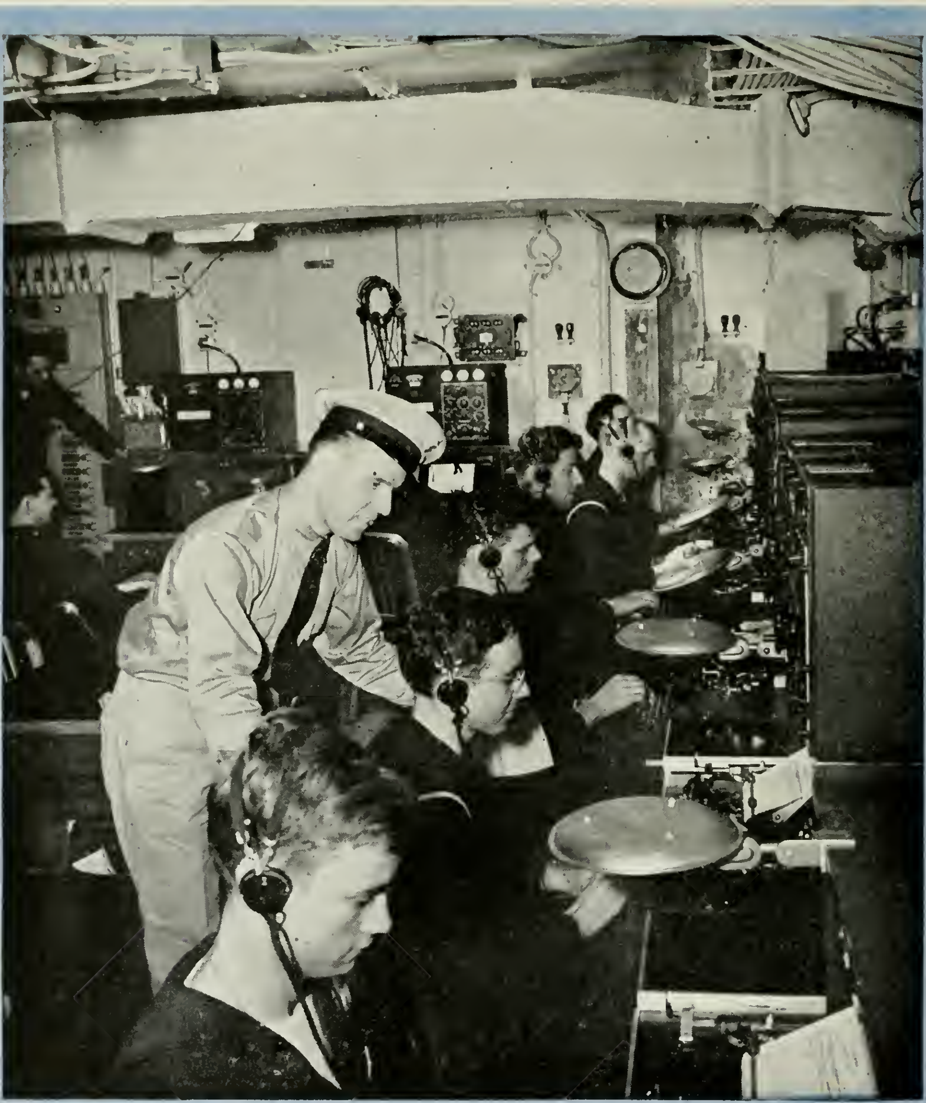
Ships of the Navy must receive instructions and information at all times, but often they themselves must maintain radio silence for days and weeks on end. They cannot acknowledge messages received, however important.

For such circumstances, flow of communications to the ships must be absolutely sure.

The chart above indicates the network of stations which provides this service, one of the most vital to the Navy.

PARADE OF POWER

AIRCRAFT CARRIERS, battleships, and cruisers, part of the Third Fleet. Below: a battlewagon in silhouette



EARS OF THE NAVY

This is the central radio receiving room of a battleship

Between Ships at Sea

BETWEEN ship and ship, and between ship and shore, ordinary radio cannot be used for considerable periods, to prevent the enemy from detecting the location of forces afloat.

Great ingenuity guards the secrecy of communications at sea. That these methods are effective is indicated by the number of times that the enemy has been surprised. Ultra-short wave is used for tactical control of ships.

A modern carrier has 101 radio circuits, a modern battleship 77, even a torpedo boat has seven.

THE pilot talks by telephone with his tail gunner (above) as well as by radio with the carrier. Below: Receiving a radio message aboard a speedy PT boat

ABOVE: Pilots aboard a carrier listening to inter-plane conversations of fellow pilots in action against the enemy

TELEPHONES and loud speakers are vital to a carrier's control of her planes. Left: In the wheelhouse of a PC boat

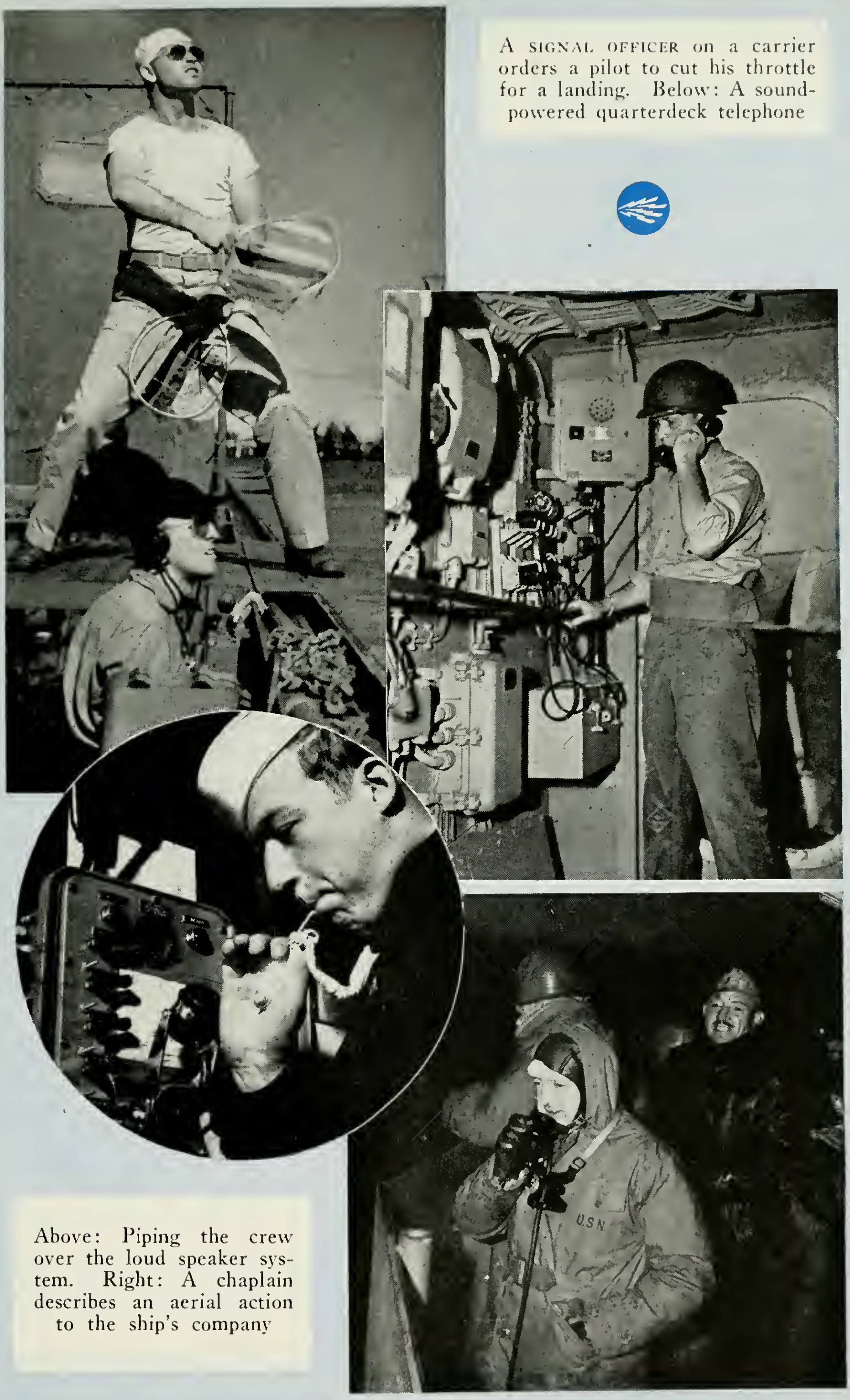
On Shipboard

TELEPHONES aboard ship, vital to interior communications, range from the glamorous "Admiral's phone" to the multitude of sound-powered instruments linking action stations and command positions.

The dial system of a battleship is similar to that of any large city. A commanding officer may be instantly in touch by telephone with any of his staff. Sound-powered telephones, besides needing no electrical power, provide conference communication: for example, a gunnery officer can speak to all the gun crews under his control simultaneously.

A single battleship requires about 2,000 instruments. The hand-sets already produced for the fleet approach the total civilian installations of Washington, D. C.

A SIGNAL OFFICER on a carrier orders a pilot to cut his throttle for a landing. Below: A sound-powered quarterdeck telephone



Above: Piping the crew over the loud speaker system. Right: A chaplain describes an aerial action to the ship's company

PANORAMA OF INVASION
Part of the armada used in the landings on Okinawa

Amphibious Operations

COMMUNICATIONS are the core of amphibious operations. It is necessary for hundreds of surface craft and aircraft to perform tasks specified for each on a schedule laid down to the minute, and this must be done despite weather and the enemy.

All forms of communications—electronic, visual, and voice—here are in use at once in a small area. The commander afloat receives exact information of what happens on the beach in order to regulate the conduct of the operation, the control of supporting naval gunfire, and the order in which men and material flow into the action.

ABOARD a Coast Guard vessel, communications men keep in touch with operations ashore. Below: Marines set up radio equipment on a recently captured beach

THESE MARINES are awaiting word that another telephone line is hooked up on a Pacific island. Right: With his handy-talkie, this Coast Guardsman helps control traffic to and from a busy island beach

PLANES OF "NATS"
They fly precious cargoes far over lonely waters

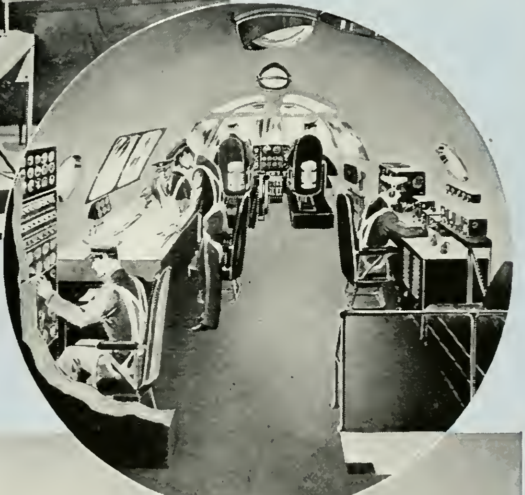
Naval Air Transport Service

THIRTY DAYS after Pearl Harbor, the Naval Air Transport Service began with three aircraft. Today nearly 450 planes move high-priority freight and personnel all over the world.

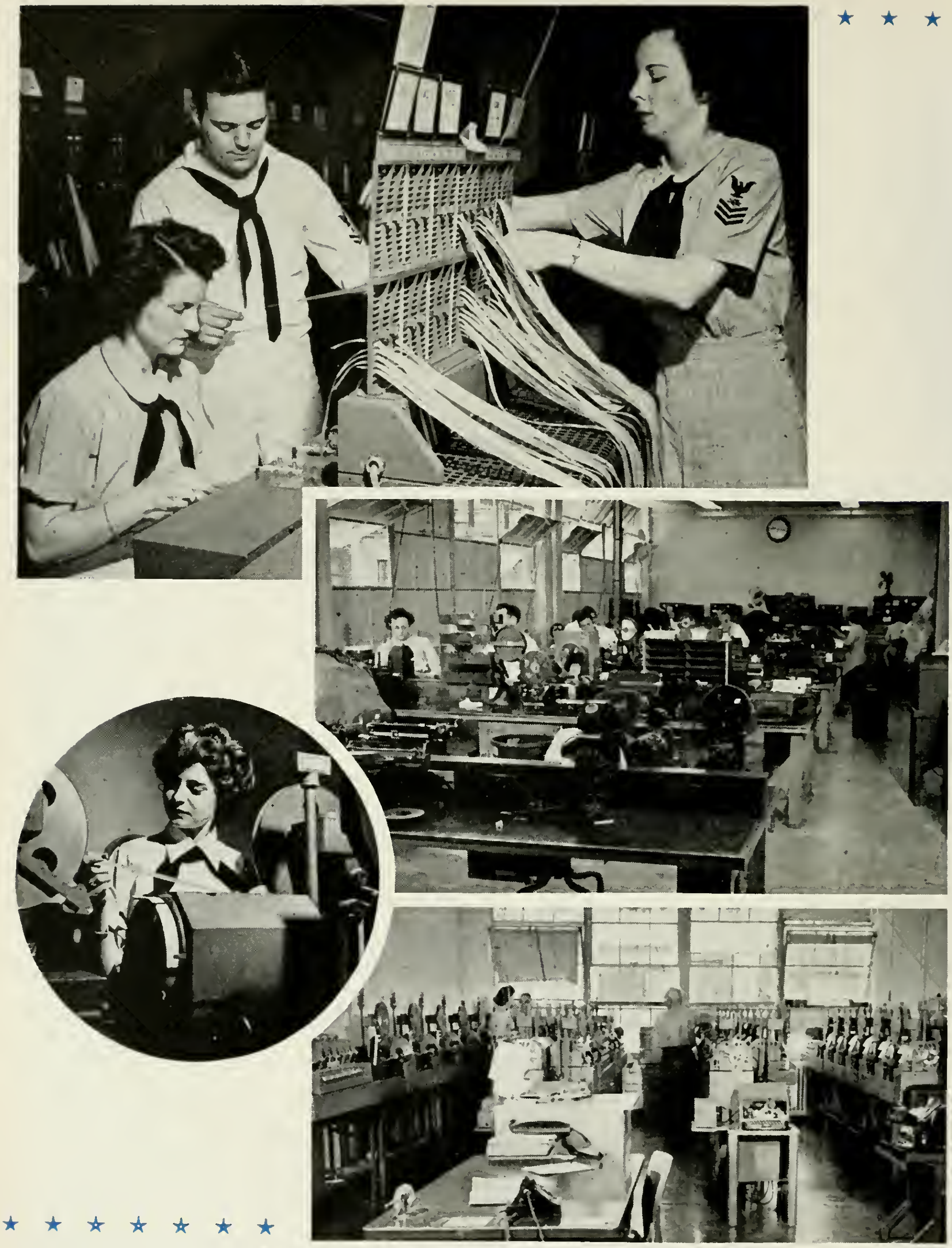
To carry out this task, a system of communications is vital, and NATS has its own which has grown as the areas of combat have spread. It must be possible to reach every base and every plane at all times over routes which cover 65,000 miles.

Among the manifold duties of the Naval Air Transport Service is the movement of wounded from the battle zones to hospitals in the Pacific, and from the hospitals to the United States.

WAVES operate many Naval Air Station control towers. Left: bringing the wounded back to hospital



BELOW: The NATS flying boat MARS; and, right, a sketch of the plane's interior



Navy Communications Center

THROUGH this Navy Department communications center passes the direction of this nation's Naval warfare. It is the heart of all Navy communications. Through it, at any time of day or night, the Navy Commander in Chief can reach, directly or indirectly, any station, any officer, any vessel in any part of the world. More than 5,000 Waves are assigned to communications work.

Improvements in Speed of Service, Accuracy, Uniformity, Dependability, and Economy Will Result When Toll Calls Can Be Dialed Straight to the Called Telephone

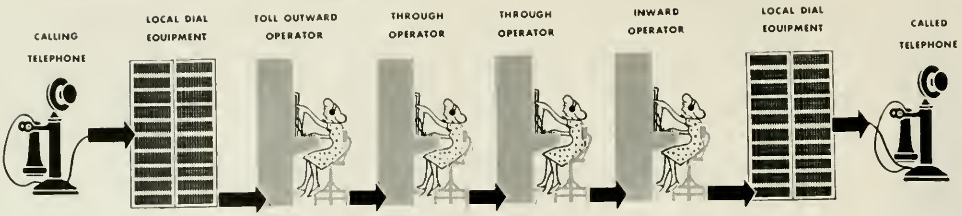
Operator Toll Dialing—A New Long Distance Method

James J. Pilliod and Harold L. Ryan

Within the next several years following the end of the war, methods and equipment will be available which will enable Bell System long distance operators to dial calls, directly and unassisted, straight through to the called telephone even though it be at the other side of the continent. Assuming the completion of the System's local dial service program during the next decade, this means that by about the end of that period a call from any telephone in the System may reach practically any other telephone anywhere in the country, swiftly and accurately, through the services of just one operator. The plan is sufficiently comprehensive to provide for the inclusion of offices of independent telephone companies which desire to participate.

Two developments now under way, among the many factors involved in a project of such importance and great scope, will be the principal contributors to the accomplishment of System-wide toll dialing. One of these is a new system of toll dial switching equipment which functions, in response to the operator's dial, with uncanny discrimination, accuracy, and capacity for performing many operations economically. The other is the toll dial operating method itself—of which an important element is a nation-wide numbering plan which may be universally used by all outward long distance operators to complete a call to a telephone reached through any central office connected with the nation's toll network.

Operator toll dialing offers impressive opportunities for further improvement in the speed of long distance connections, in the accuracy and reliability of the service, and in overall economies of operation. To appreciate how long distance service will go ahead in the next several



Diagrammatic representation of manual toll operation. The operators in different cities are linked together by toll circuits

years, it may be helpful to recall how far it has come in the last twenty-five.

Operating Methods: Past and Present

Twenty-five years ago, the average speed of service on long distance calls was 14 minutes. By 1940, the year before the war, it had been reduced to 1.4 minutes. Along with this improvement in the speed of service, clearness of transmission has been increased, and rates have been reduced 30 percent on the average—and more on the longer hauls. In 1920, it cost $16.50 to make a station-to-station call from New York to San Francisco; now it costs $2.50.

THE SEPARATE LINE AND RECORDING METHOD

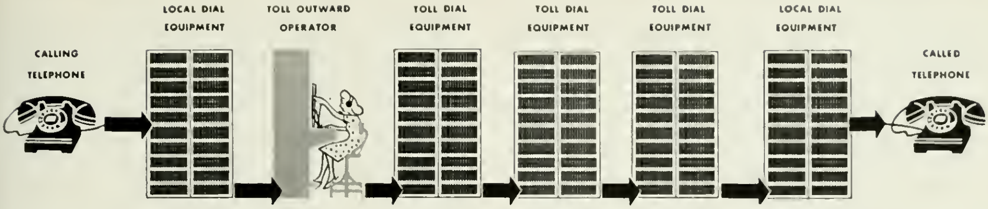
In 1920, the System was almost wholly manual, and long distance calls averaged only about 700,000 a day. In making a long distance call, the customer lifted his telephone receiver and asked the local "A" operator for "Long Distance." She connected him with a toll recording operator, who recorded the details of the call on a toll ticket and then said to the customer, "Thank you. I will call you."

The ticket was then sent by messenger—or in some of the larger offices by pneumatic tube—to the toll outward operator. She picked up the customer's line through a "B" operator in the local office, selected a toll line, rang, and—in the case of a switched call—asked each successive through operator for the called place until the inward operator at the terminating point was reached. She then asked the inward operator to connect to the called telephone, which the latter did through the local "B" operator. It was necessary for the outward operator to remain in on the connection until the answer at the called telephone and the start of conversation. In general, the establishment of a two-switch connection by the single ticket method involved eight operators and in most cases a messenger.

During the next five years, largely through more adequate circuit and equipment facilities, better maintenance, and improvement in toll office management, the time required to complete connections was cut approximately in half—from 14 to 7.3 minutes.

THE COMBINED LINE AND RECORDING METHOD

Conversion from the separate line and recording method of operation



DIAGRAMMATIC representation of operator toll dialing. The equipment in different cities is linked together by toll circuits

to the combined line and recording method, commonly called "CLR," started in 1926. By that time the conversion of manual offices to dial was well under way, and already about 15 percent of the System's telephones were dial operated. By 1935 they had increased to nearly 50 percent, and about two-thirds are now dial.

With the CLR method and dial service, the customer dials a code number and is connected directly to a toll operator who combines the recording of the call with the line work. This by-passes the local "A" and recording operators and the messenger. The customer is held at the telephone while the connection is completed—or the first attempt is made—thus avoiding recalling the customer. As under the former method, the line operator advances the call to the inward operator at the called place and the latter makes the connection directly to the called telephone by dialing, generally without the aid of the local "B" operator at the terminating point. Instead of eight operators and a messenger, as under the earlier method, only four operators are concerned with the completion of the connection on a two-switch call. The reduction is due in part to CLR operation and in part to the use of dial central office equipment.

Along with the introduction of the CLR method, considerable improvement also was made in transmission, and the number of switches required to complete calls was reduced through the introduction of the General Toll Switching Plan and the provision of the necessary circuit facilities to make it operative. This plan set up eight regional centers, at New York, Atlanta, Chicago, St. Louis, Dallas, Denver, Los Angeles and San Francisco—all of which are directly interconnected. To these regional centers are connected some 140 primary outlets throughout the country, and to these in turn are connected all the rest of the toll centers—some 2400. This makes it possible to complete a call from any toll center to any other toll center with a maximum of four switches.

Extension of the CLR method, improvement in transmission, reduction in the number of switches, better toll line engineering methods, and improved central office procedures for handling calls under the CLR method had resulted by 1930 in 82 percent of all long distance calls being handled while the customer remained at the telephone and in improving the speed of service to 2.1 minutes. The public response to these service improvements was immediate.

The period from 1930 to 1935, the depression years, was utilized to develop to a high degree the "know-how" of handling toll board traffic; and as a result, by 1935, 92 percent of the calls were handled while the customer remained at the telephone and with an average speed of 1.4 minutes.

By 1935, also, practically full account had been taken of the speed advantages inherent in the combined line and recording method. Although marked improvement was made between 1935 and 1940 in accuracy and in the tone and manner in which service was rendered, no further improvement was achieved in the speed of service.

The Toll Dialing Method

Operator toll dialing is already in limited operation, more than 130,000 calls a day, or about five percent of the daily 2,700,000 toll board calls, being handled over Bell System lines by this method.

Briefly, under this method the customer dials the usual code to reach the outward toll operator, who in turn completes the call to the distant telephone through toll dial equipment without the assistance—in most cases—of another operator. The four operators involved in the completion of a two-switch call under the CLR method would thus be reduced to one if such a call were handled by the toll dialing method.

With this method, on a station-to-station call, the toll operator, after dialing the necessary codes and the called number, can cut out of that connection and proceed with other calls, since she will receive a signal when the called telephone answers or another signal if the called subscriber's line is busy. If the circuits are busy, she will receive a signal, and when a circuit becomes available another signal will tell her to dial again. Provision is made for the operator to reach toll inward, information, and other operators if their assistance is necessary in the completion of calls.

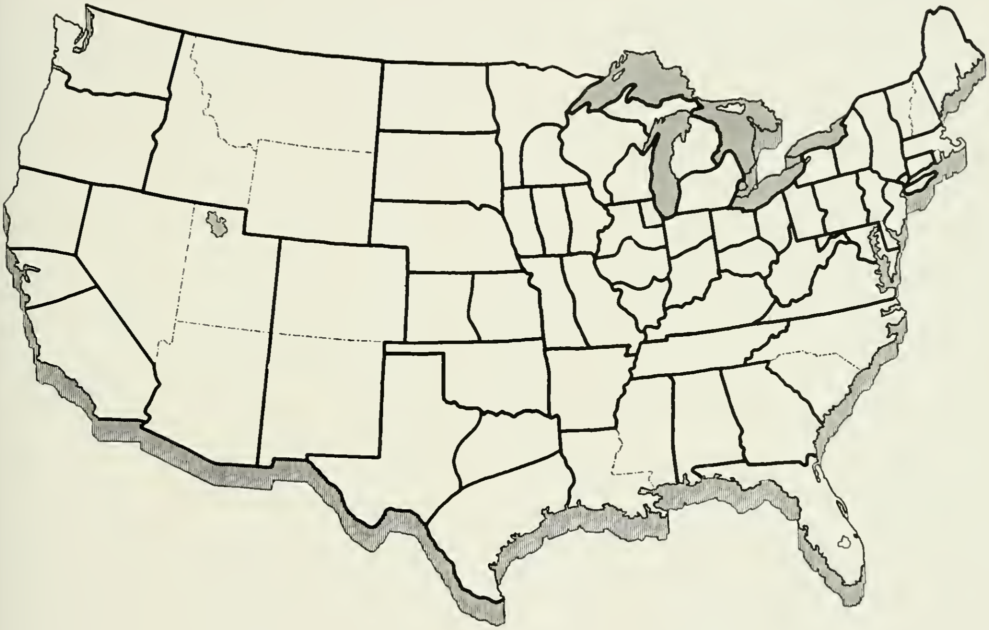
Before describing in detail how long distance calls will actually be handled under the proposed operator toll dialing method, however, it will be necessary to point out the principal features of the universal numbering plan, which is a necessary adjunct of the operating method.

THE UNIVERSAL NUMBERING PLAN

Development of nation-wide operator toll dialing requires, as a concurrent step, development also of a nation-wide numbering plan and a simple scheme of destination codes for being able to reach any toll center in the long distance network and thus any central office and any telephone. Through this plan, the same code can be universally used by all outward operators for reaching any particular office, and this code is passed along by the equipment and re-used at all intermediate switching points. (Shorter-haul calls will continue to be completed without the use of the national toll codes.)

To set up this universal numbering plan, the country is being divided into from 60 to 75 numbering-plan areas. Each of these will be designated by a distinctive three-digit code. Each office within an area will be designated by a three-digit office code, not conflicting with the code of any other office within the area nor with any area code. Thus each office in the country will be assigned its own distinctive six-digit code made up of a three-digit area code and a three-digit office code. In order to make this plan truly nation-wide in scope, provision is being made for the inclusion of independent telephone offices where desired by the independent telephone companies.

Any toll call can be completed by dialing a maximum of 10 digits: the six digits of the area and office codes and the four digits of the called telephone number. On calls between points in the same numbering plan area, the area code will not be required and only seven digits need be dialed. Area codes will contain the digit "1" or "0" in the first or second place, while office codes will never have those digits in the first or second place. This enables the equipment to recognize from the first two digits dialed whether a 10-digit inter-area or a seven-digit intra-area call is being made.



How the country might look when divided into approximately 60 areas for the nation-wide numbering plan

The accompanying map illustrates how the country might be divided into areas for such a nation-wide numbering plan. It will be noted that the boundaries of the numbering plan areas generally follow state lines. To the extent that it is feasible, an entire state will be included in one numbering plan area, so that the operator can readily associate the numbering plan code with the state name. Examples of this are the States of Washington, Maine, Connecticut, and New Jersey.

The larger states, such as New York, Illinois, Texas, and California, will be divided into two or more numbering plan areas each; and in some cases, such as North and South Dakota, it will be possible to combine two states in the same numbering plan area.

No change of customers' telephone numbers nor of local dialing practice is necessary.

For the three-digit office codes which designate the offices within a numbering plan area, and which will be non-conflicting, the first two letters of the community or office name plus a numeral will generally be used. These codes are for the use of toll operators only. For the seven-digit cities with two-letter five-numeral numbering plans for customer use, operators will use the same office codes as customers. It is anticipated that all seven-digit cities will be on this basis by the time the new routing system is widely adopted. For six- and five-digit cities, the code for the use of toll operators will be the existing office code with one or two added digits. For four-digit offices, the code will be three added digits.

On many calls, the entire routing code can be derived from the information furnished by the calling customer with reference only to very simple code information on the bulletin at the operator's position. For example, on a call from Fargo, North Dakota, to Newark, New Jersey, MArket 2-2100, the Fargo operator would determine from her bulletin that the New Jersey code is, say, 312 and would dial 312 followed by the listed number MA2-2100. On a call to Newark from Camden, New Jersey, both of which are within the same numbering plan area, the area code would not be required and the operator would simply dial the listed number MA2-2100.

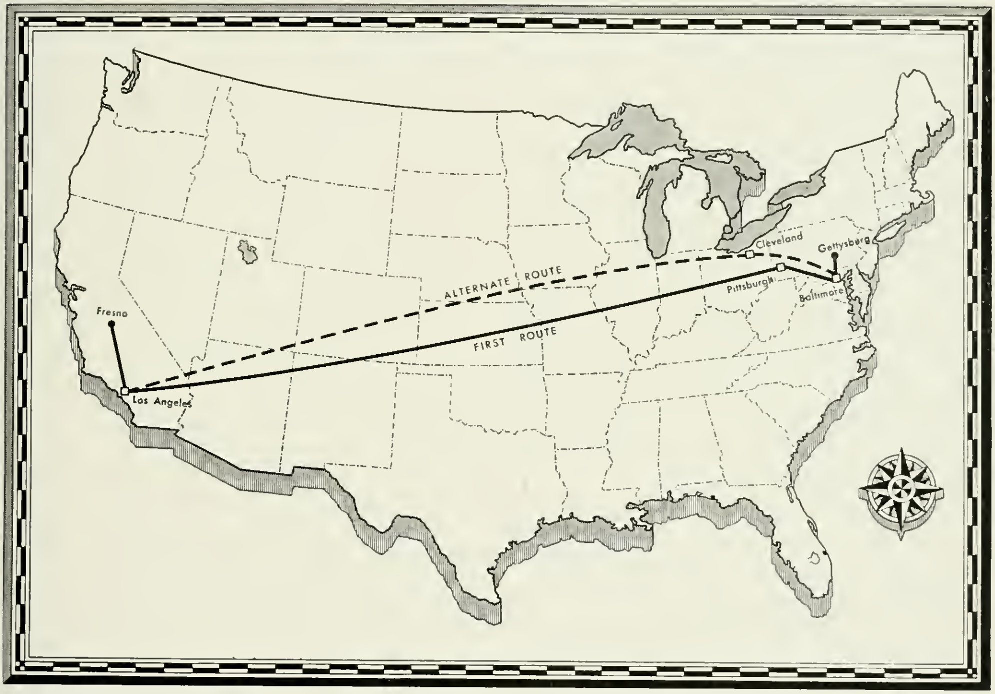
There are numerous cities located near state boundaries which have close community of interest with places just over the boundary. Well-known examples of this are Philadelphia-Camden, New Jersey; Detroit-Windsor, Ontario; and Washington-Alexandria, Virginia. Wherever possible the area around such cities will be included in the numbering plan area of both the adjacent states. Central office code conflicts in the adjacent cities will be eliminated and this, together with their inclusion in both numbering plan areas, will make it possible for operators to dial across the state boundaries without the use of numbering plan area codes. With such an arrangement an operator in Philadelphia may dial a number in Camden using only seven digits, but would have to dial ten digits to reach a Newark number.

HOW THE CALLS WILL BE DIALED THROUGH

ONCE the toll dial switching equipment is in place, and the universal numbering plan is fully in effect, just how will an outward toll operator go about dialing a long distance call through to its destination anywhere in the country?

A call from Gettysburg, Pa., to

Fresno, Cal., a three-switch call, will illustrate. But before describing a method of the future it may be well to review the present method, to emphasize the contrast.



Routing a call from Gettysburg, Pa., to Fresno, Cal.

The routing of many calls across the country involves one or more switches which are made at toll centers, usually primary outlets or regional centers which have been specially designated and equipped for this purpose in accordance with the principles outlined in the General Toll Switching Plan. These switching points, together with about 175 additional toll centers, making about 325 in all, have been selected for operating purposes as the key points in the toll routing network and designated as Class 1 offices.

Each central office in the country is connected to a toll center, which, if not one of the 325 Class 1 toll centers, has direct circuits to one of them. The 325 Class 1 toll centers either have direct circuits to the others or know the first intermediate point to reach in the direction of the called place. Therefore, all an operator needs to know to route a call is the toll center serving the called community and the Class 1 toll center through which its inward and outward traffic is routed. (Approximately 80 percent of all calls are completed over direct circuits and no routing information is required. Of the remainder, about 17 percent are one-switch and 3 percent are multi-switch.)

Under the present CLR method of operation, when a customer in Gettysburg places a long distance call to Fresno, the Gettysburg operator goes to the routing directions and finds that Fresno is a toll center and that Los Angeles is its Class 1 office. The Gettysburg operator reaches Baltimore, which is its Class 1 office, and says to the Baltimore through operator, "Fresno, Cal., via Los Angeles." Baltimore says, "I will give you Pittsburgh," which is its route to Los Angeles. Reaching Pittsburgh, the Gettysburg operator again asks for Fresno via Los Angeles. Since Pittsburgh has direct circuits to Los Angeles, the next office answering will be Los Angeles, and the Gettysburg operator will then ask for Fresno, and when Fresno answers will give the operator there the called number.

If the circuits from Baltimore to Pittsburgh are busy, an alternative route will be used, the Baltimore operator saying, "I will give you Cleveland," and the advancement of the call will follow the procedure already outlined.

How, THEN, will an operator complete so long and relatively complex a call at some future time?

In order to have the necessary switches made at intermediate points under the nation-wide operator toll dialing plan, the operator needs to know only the area and central office codes. Since Fresno is a five-digit city, the national toll code would be, for example, 514 for the numbering plan area and 37, which is FR on the dial, added to the five digits of the listed number, making 10 in all.

Assuming for comparison that the future routing would be the same, the Gettysburg operator would take up a circuit to Baltimore and dial the 10 digits into sender equipment located at Baltimore, a control switching point. (See map on page 107.) Baltimore, Pittsburgh, Cleveland, and Los Angeles are control switching points which might be used in the completion of this call. The equipment at Baltimore would translate the national toll code and determine that the first route is via Pittsburgh. It would select a Pittsburgh circuit, if one were available, and would send along the entire 10 digits dialed by the Gettysburg operator. (Incidentally, the pulsing system used between control switching points will be much faster than the step-by-step pulses generated by the operator's dial.)

At Pittsburgh the equipment would select a Los Angeles circuit but would transmit forward only the Fresno central office code and telephone number, since Fresno is in the same numbering-plan area with Los Angeles. If the Baltimore-Pittsburgh circuits were all busy, the equipment at Baltimore would automatically try the alternative route through Cleveland and the Cleveland equipment would advance the call to Los Angeles.

At Los Angeles—the last control switching point assumed here—the equipment would select a circuit to Fresno and would convert the pulses received from Pittsburgh or Cleveland to the correct number of step-by-step digits and send them out over the circuit to control selection of the called subscriber's telephone at Fresno.

If the call were for a telephone served by an office tributary to Fresno, the operator at Gettysburg would dial 10 digits as on the call to Fresno, but, of course, with a different office code. When the call reached Los Angeles, the equipment there would recognize from the office code that the call was for a tributary of Fresno and would prefix to the called number sent out over the Fresno circuit the necessary digits to perform the switching operation at Fresno.

Present Step-by-Step Toll Dialing

Operator toll dialing will ultimately work throughout the length and breadth of the country. But before discussing the equipment through which it will function, it is necessary to digress here for a moment to describe a method of operator toll dialing now in daily use over limited areas, and to point out why new types of equipment are necessary to expand it to operate on a System-wide basis. This method of limited range is known as step-by-step toll dialing.

Many hundreds of communities, small and moderately large, have for years been furnished local telephone service through step-by-step dial central offices, and the local dial equipment can be readily adapted to fit into the new toll dialing plan. Gradually the reach of the dial mechanism has been extended out to neighboring towns and cities—even to those at some distance—and today operators are dialing toll calls over step-by-step toll dialing networks over fairly wide areas in Connecticut, Ohio, Michigan, and other places.

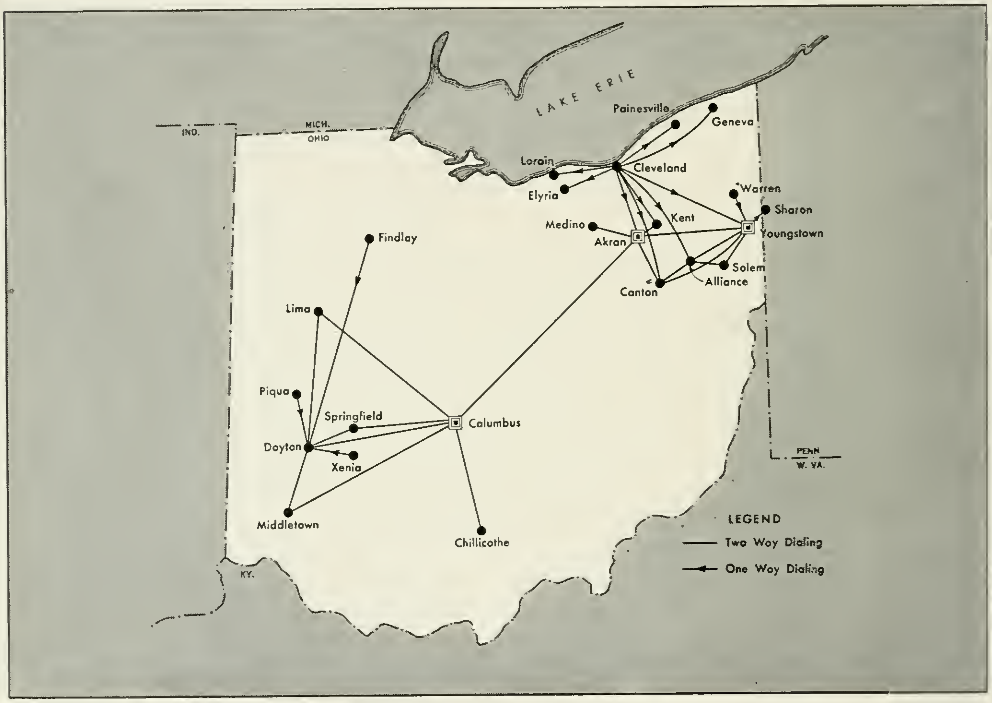
In brief, the operator, after receiving from the customer the number he wants in another place, takes up a circuit to the called place and dials the called number, or, in the case of a switched call, first dials a code to secure a circuit to the point beyond and then dials the called number.

For example, on a call from Middletown to Columbus, Ohio (see diagram on page 110), the operator at Middletown plugs into a toll circuit to Columbus in her multiple and dials the Columbus telephone number as listed in the directory. If the call is to Akron, the Middletown operator likewise plugs into a circuit to Columbus, but dials a code which causes the switches at Columbus to connect her with a circuit to Akron and then dials the listed number at Akron. If she were authorized to dial through to Youngstown, she would reach Akron as on an Akron call but would then dial an additional code to reach Youngstown and then the Youngstown listed number.

Obviously, this method could be extended to any number of switches, transmission permitting; but note that each switch involves the dialing of additional digits by the operator. On a three-switch call, as many as 16 digits might have to be dialed.

Under this method the operator must know the exact route and must have, before she starts to dial, the codes necessary to get through each of the switches involved. Moreover, if the circuits at any point along the line are busy, she must obtain a new set of codes to dial in order to try an alternative route.

Furthermore, calls from step-by-step points cannot be dialed into the large cities served by panel dial equipment without special signal conversion arrangements in those cities. Some form of equipment other than present types of step-by-step toll equipment is required at these larger cities if advantage is to be taken of possible simplifications in coding systems and operating methods and if economies in trunking arrangements are to be realized.



A DIAGRAM of the Ohio step-by-step toll dialing network

For these and other reasons, step-by-step toll dial equipment alone is not practical on a nation-wide basis.

None the less, such localized step-by-step toll dialing networks are serving well the particular needs of shorter-haul traffic, and they will have other counterparts all over the country among communities which have many interests in common and will form an important part of the national system.

Crossbar Toll Switching Equipment

SINCE step-by-step toll dial equipment alone has been found not to be adequate for a nation-wide toll dialing system, let us see what kind of dial equipment will accomplish this much desired operation.

For satisfactory nation-wide operator toll dialing, it is obviously necessary to have the equipment determine the routing. On this basis, a code is assigned which represents the destination of a call, the dial equipment selects the route, operates switches at intermediate points, tries alternative routes if necessary, and completes the connection.

For the larger places the No. 4 toll switching system, already in service in Philadelphia, will, with slight modifications, be adequate. This system permits calls originating in surrounding step-by-step networks to be dialed into the Philadelphia panel and crossbar dial offices for completion or to be routed from one step-by-step network through Philadelphia to other step-by-step networks.

This new system utilizes crossbar switching equipment and is of the common control type, providing a high degree of flexibility and speed in the handling of calls. The common control equipment enables the called number to be registered in storing circuits, called senders, after which it is analyzed, or "translated"; and then, depending on the destination of the call and the type of switching equipment which will be called upon to complete it, a choice of routing and pulsing is automatically determined, a circuit to the called point is selected, and the signals which will locate the called number are forwarded to the destination. At this stage, the common control equipment is released, and thus becomes available for handling other calls. The equipment functions as an outward toll tandem board, an inward toll board, and a through switching toll board, but does not replace outward positions of the present type.

For busy periods when toll lines are congested, operators are located at a group of delayed-call positions and these operators can complete the calls in the order of filing as circuits become available.

Important transmission improvements and economies are obtained by the use of four-wire switching through the equipment and the automatic switching-in of repeaters whenever they are required.

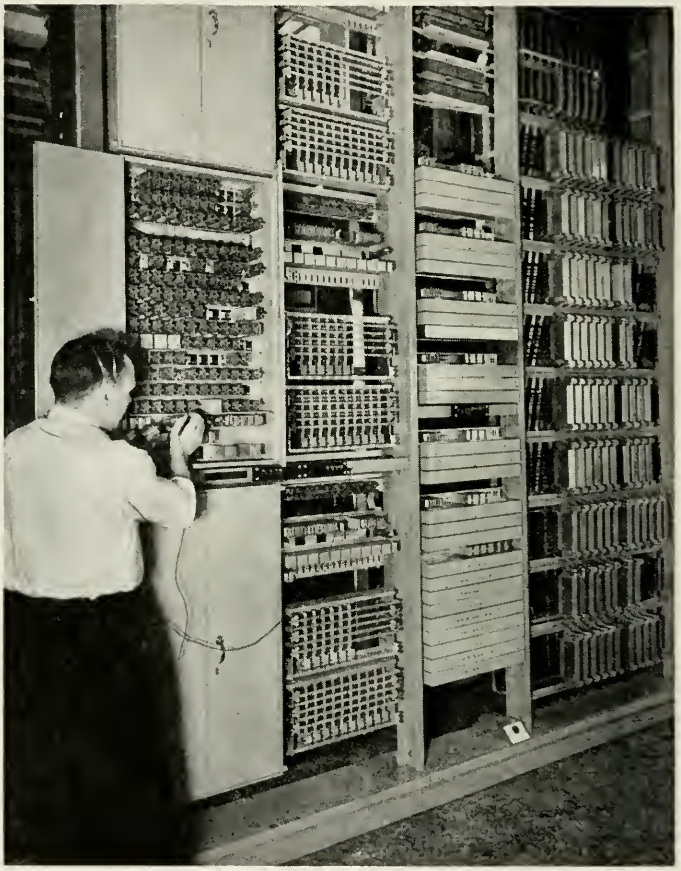
The No. 4 equipment can receive the called number in terms of dial pulses or of pulses from operators' key sets. For inward ringdown or straightforward calls it provides positions of the call-distributing type without cords or multiple at which the operators key up the desired number, thus recording it in the sender and permitting the completion of such calls as if they had been dialed by the outward operator at the distant end. Completion of calls through any kind of dial equipment or to manual offices is provided.

Experience with the Philadelphia installation demonstrates that this type of equipment, with appropriate modifications, can be used in a nation-wide operator toll dialing system.

While the present No. 4 system includes most of the features required for nation-wide operation, additional features are also being incorporated to make provision for selecting the most direct route to a distant city. It is to be expected that, as in any new enterprise, continued changes will be made as improvements are devised and greater experience is gained.

Transmission of Signals

From the description of the new operator toll dialing system given so far, it will be evident that the long distance transmission and reception of signals or pulses will be an important factor in selecting toll circuits, establishing connections, and, finally, in giving the outward operator supervision of both ends of the connection. Arrangements must also be made for the disconnection of circuits at through switching points under the control of the outward operator.



Operators in distant cities dial into "senders" which control the connections through the No. 4 toll switching system

These signals must follow the general route of the call, but need not be transmitted in all cases over the same circuits on which the conversation takes place. In some cases, direct current circuits will be used between cities, but for the longer distances it is expected to employ voice frequency or carrier circuits.

In any event, the technique of long distance transmission of telephone and telegraph currents which has been so extensively developed in this country will play a most important part in the extension of toll dialing.

Building on the General Toll Switching Plan

The references already made to the General Toll Switching Plan emphasize the importance of its part in the development of nation-wide toll dialing.

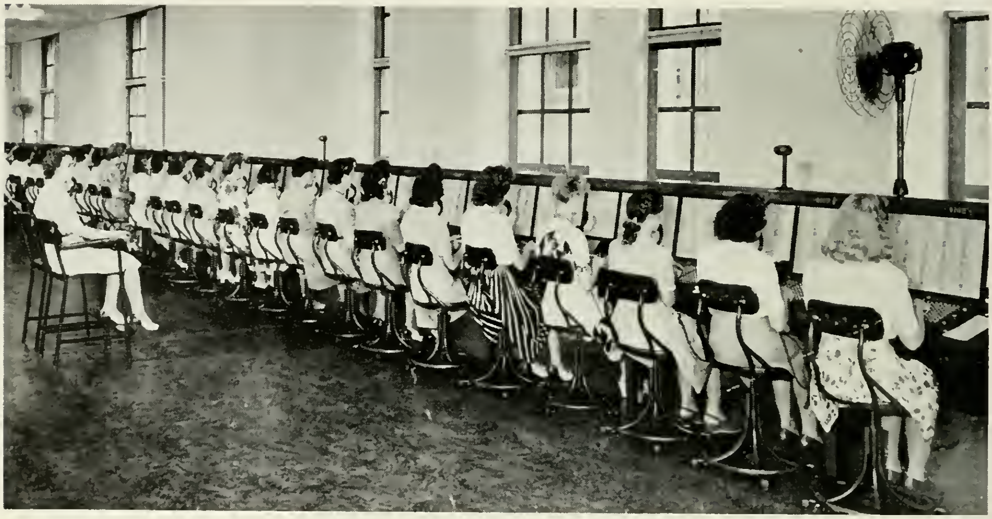
This plan provides the basic routing arrangements, under existing methods of operation, for all calls which require one switch or more at intermediate points. Each toll center is connected to a primary outlet and each of the latter is connected to at least one regional center. All regional centers are interconnected with each other, and it will be evident, therefore, that a call from a toll center at one end of the country to a toll center at the other end would as a maximum require four switches and be routed as follows:

> Toll Center *to* Primary Outlet *to* Regional Center *to* Regional Center *to* Primary Outlet *to* Toll Center

Fewer switches would be required in practically all cases because the eco-

Connections are established on a four-wire basis through the noble metal contacts of crossbar switches in the No. 4 toll switching system nomical design of the toll plant has resulted in the establishment of direct circuits between many points at great distances from each other and thereby provided more direct routes not requiring so many intermediate switches.

The General Toll Switching Plan forms a firm foundation on which to build the extension of toll dialing. Using this plan, with the major switching points already established for manual operation, it appears practicable to locate crossbar switching systems providing the features necessary for "control switching points" at important switching centers, including the present regional toll centers and most of the present primary toll outlets. Thus provision of "control switching" equipment at not more than 150 points will be adequate to give every outward operator in the 2400 toll centers direct access to such equipment. The remaining toll centers may have step-by-step toll equipment or a simplified form of crossbar toll equipment.



CORDLESS positions for setting up calls from cities not yet arranged for toll dialing

A Long Stride Ahead

WHILE complicated central office mechanisms are required at "control switching points" to make operator toll dialing possible on a country-wide basis, it is apparent that from the operating standpoint this method of handling long distance calls is simple in the extreme. Its advantages have been implied throughout this discussion; they may be summarized briefly thus:

1. By 1940, average speed of service on all Bell System long distance calls had been brought down to 1.4 minutes with an average of about three minutes on multi-switch calls.

With toll dialing, the speed on multi-switch calls is expected to be close to that of direct-circuit traffic and the average speed about one minute.

2. The service will be more accurate and less subject to interruptions and cut-offs.

3. The service will be more uniform and dependable, since fast inward and through service will be available twenty-four hours a day to the full extent of available facilities. The value of this in peaks of traffic and in emergencies during off-hours is apparent.

4. Fast switching will reduce holding time, and automatic alternative routing will make more routes and circuits available for a given call, thus tending to make more efficient use of the toll circuit layout.

AMONG the Bell System's many constructive post-war plans for developing and improving the nation's telephone service, the provision of operator toll dialing has an important place. It will bring to the country's telephone users a faster, more efficient, more dependable—and therefore more useful—long distance service. Much work will have to be done in the years immediately ahead; but accumulated experience and the present toll plant together provide a sure foundation on which to build the bold new structure.

WITHOUT CONTINUOUS TECHNOLOGICAL IMPROVEMENT the Bell System would not have been able to give an adequate or nation-wide service, even if it would have been able to give any service at all. And without continuous technological advance the Bell System would not have employed much of anybody, nor would it have served the economy and speed of other businesses so that they would employ more people. And without continuous technological advance there would not have been either increased values or reduced rates to the public, and certainly no added income to devote to increased wages for the employees.

From "The Bell Telephone System," by Arthur W. Page, Vice President, A. T. & T. Co. Harper & Brothers, publishers, 1941.

As the War against Japan Gains in Power, Increased Activity on our Western Shores Brings Greater Problems to the Pacific Telephone and Telegraph Company

The West Coast in the War

George H. Jess

WAR CONDITIONS have resulted in many unusual telephone construction and service problems throughout the territory of the Pacific Telephone and Telegraph Company. The telephone tasks already accomplished, together with the amazing changes that have taken place, make the period dating from the Pearl Harbor attack seem incredible—even from the present perspective, with the war centered in the Pacific.

The Pacific Company with its subsidiaries, the Southern California Telephone Company and the Bell Telephone Company of Nevada, operates in five states: California, Nevada, Washington, Oregon, and Northern Idaho. The plant of the company was, of course, designed to meet the peace-time needs of developed areas. And in this western country of wide open spaces, developed areas constitute a relatively small part of the territory covered by the company's operations, which comprises 435,000 square miles or 15 percent of continental United States.

When war came, military establishments sprang up like magic throughout the Coast, without consideration to available communication facilities. It followed inevitably that hundreds of miles of new telephone construction were required to serve these reservations, stations, camps, air fields, hospitals, and so on. And there was a further necessity for releasing large numbers of vitally needed toll circuits to serve the Army and Navy, and provide private line networks for tactical operations.

In the years 1942 and 1943, there were 220 Army camps established on the Coast. This brought to 332 the grand total of camps established before and after the war began. The Navy, at the same time, had 196 establishments. There were also 117 government-owned war industries adding to the communications requirements by the end of 1944. In the early part of 1945, the telephone company was serving approximately 100,000 private branch exchange stations in these installations.

Between June, 1940, and the end of 1944, almost three and one-half billion dollars were spent on the Coast for establishments of the Army, Navy, and war industries. For example, aircraft plants increased from nine, with a production of 2,600 airplanes in 1940, to ten major plants in 1944, which produced 25,189 planes during that year, or 26 percent of the entire output of the nation.

HEAVY INDUSTRY has made great strides and great contributions since Pearl Harbor

Shipbuilding rocketed from nine shipyards in 1940, producing 12,000 deadweight tons, to 34 shipyards in 1944, producing 6,300,000 deadweight tons. The number of ships launched on the Coast in 1944 was equal to 39 percent of the nation's output of maritime ships in that year. And the term "maritime ships," as used here, excludes vessels built under contracts with the Army and Navy, but does count some special ships, such as LST (Landing Ship Tank).

These aircraft and shipbuilding

plants employed more than 760,000 people at the end of 1944, and they accounted for the lion's share of total war supply contracts on the West Coast through the year 1944. These contracts through the year 1944 amounted to over twenty-two billion dollars, or more than the national debt in 1932.

This large-scale building of ships and planes caused overnight changes in many towns and cities. Typical communities of peace-time America became roaring centers of war production. Take Richmond and San Diego as examples. Richmond, which during March, 1945, had five major shipyards employing approximately 67,000 people, grew from an industrial city of 30,000 in 1940 to a war center with a population of 122,700 at the first of 1945—an increase of 309 percent. San Diego owes its 89 percent growth in population over the four-year period to Navy activities and aircraft manufacturing.

This big growth was naturally reflected in telephone traffic. In San Diego, the four years saw toll calls soar from a pre-war figure of 8,000 daily to a daily average of more than 32,000 in the early part of 1945—a 300 percent increase.

Pacific Coast airplane factories produced more than 25,000 planes in 1944

The company as a whole handled about 290,000,000 toll calls in 1944; double the total for 1940. Calls to places outside the company's territory totaled more than 7,700,000; nearly ten times the volume of four years ago.

The handling of this telephone business resulted, as might be expected, in correspondingly rapid increases in the traffic forces. Where at the end of 1940 there were 14,000 traffic employees, the force numbered almost 24,000 at the end of 1944. To secure this gain of 9,800 in the four years, the company hired and trained more than 60,000 people: a commentary on the problems encountered in coping with added volumes, inexperienced personnel, and high turnover.

At the end of 1940, the company had about 2,700 toll-center-to-toll-center circuits. As of December 31, 1944, there were more than 5,000 such circuits—which was several hundred short of meeting requirements. The growth in number of circuits to the East has been the most spectacular, increasing from 184 at the end of 1940 to 690 at the close of 1944; and these, too, were more than 300 short of requirements.

Last year, 39 percent of the nation's new maritime ships were launched on the Coast

Three Major Projects

The situation which was met by the company is well illustrated by three major projects involving gross construction costs of $14,600,000.

The first was the construction of facilities on 1,317 miles of route, including 892 miles of new pole line, between Southern California and Central Washington. This was known as the "DBR-1" route.

The second was the "Desert Training Project" of helping to provide communication facilities for a total of approximately 360,000 Army men trained in this area, beginning with General George S. Patton's armored divisions subsequently used in the African invasion.

The third involved the Pacific Company's share of constructing the transcontinental cable. Each, in turn, was characterized by Bell System "know how."

East of the Ranges

Construction of the DBR–1 pole line was described in a recent issue of this Magazine,* to which account may be added:—The line was built in collaboration with the Army to protect coastal communication in the event of enemy attack and provide service for 19 proposed airfields along the route. While used only in part for its primary purpose, this line east of the Sierra Nevada and Cascade ranges provides a needed additional toll route from Central Washington to Southern California, and has helped to meet the unprecedented traffic volumes stimulated by the war. The line cost $5,600,000 and involved about 900,000 man-hours of labor. At the end of 1944 it provided in the neighborhood of 83,000 miles of telephone circuits and by the mid March of this year it provided 101,000 miles of telephone circuits.

Prodigious quantities of lumber from the Pacific Northwest have gone into the war

Desert Maneuvers

The story of wartime telephones in the California desert for Army maneuvers is unique in communication history. When General Patton arrived on the scene in March of 1942, he drew a triangle on a map and said, "This is it." A week later, thousands of troops began to pour into the small railroad towns, form into convoys, and disappear in the desert.

The maneuver area covered 30,000 square miles—more territory than do the States of Massachusetts, Rhode Island, New Hampshire and Vermont taken together. Several of the camps were established 50 or more miles from the nearest town or telephone exchange. Telephone men on occasion had to drive 150 to 200 miles to clear a single case of trouble. A round trip of more than 400 miles was required to visit the three toll offices at Blythe, Needles, and Whitewater in this area. Eleven telephone buildings were built there, including the toll offices and four repeater stations. Thirty-seven positions of switchboard were installed, 50 private branch exchange switchboards, 2,000 telephones, more than 50 public telephones, and some 25,000 miles of physical and carrier circuits. Gross construction for the project amounted to $1,700,000, and 175,000 man-hours went into the job.

---

* See "Building the West's New Telephone Route," Magazine, Winter 1944–45.

Troops began to pitch tents at the base camp, later named "Camp Young," the first week in April. The nearest Southern California Telephone Company office was Whitewater repeater station, 65 miles away. Other "close" telephone neighbors, by desert distances, were the San Bernardino toll office of the Southern California Telephone Company, 105 miles; and the Thermal office of the independent Coachella Valley Telephone Company, 23 miles.

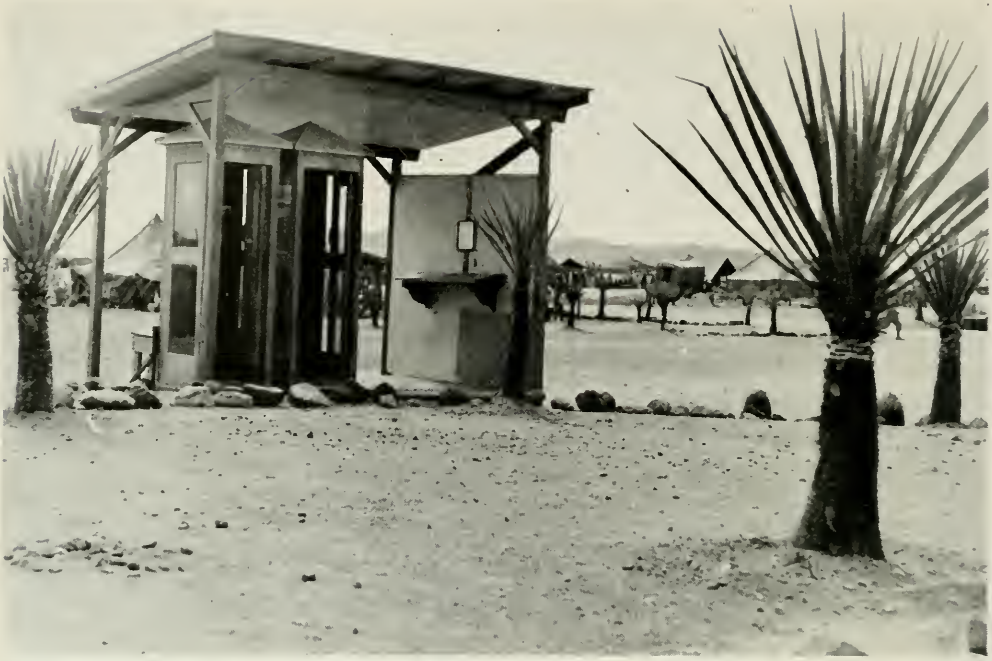
WESTERN ELECTRIC installers moved into the camp about June 1, the day the Army contractor completed the building to house the dial switching apparatus. On July 15, the 400-line dial system was placed in service, and connected with a distributing system built by the Southern California Company, covering eight square miles.

Camp Young by this time accommodated 10,000 troops. The First Corps was just getting into large-scale maneuvers when the order came to head for what turned out to be North Africa. The Second Corps poured in to replace the departing outfit. Huge troop movements and almost daily refinements in plans created an avalanche of traffic. The Army switchboards at the camp were supplemented by a mobile switchboard rushed by the company from Los Angeles.

Next arrivals were equipment experts from Riverside and Los Angeles, who worked around the clock, installing tie trunks and other modified arrangements to link the mobile equipment and the dial system. Less than 48 hours elapsed before Army personnel were operating the board under the instruction of two women traffic supervisors.

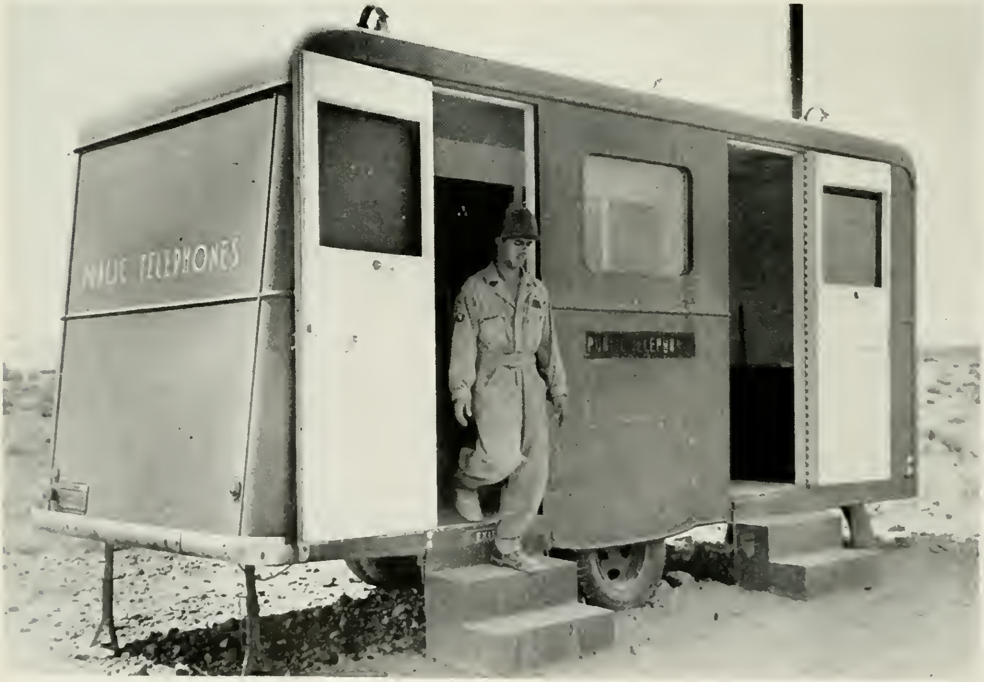
NEW PLANTS have been constructed for the production of 100-octane aviation gasoline

Many new telephone pole lines were built. By late October, a repeater station had been completed at Thermal, and the Whitewater toll office was opened to serve Camp Young. The mobile switchboard moved out, its work well done.



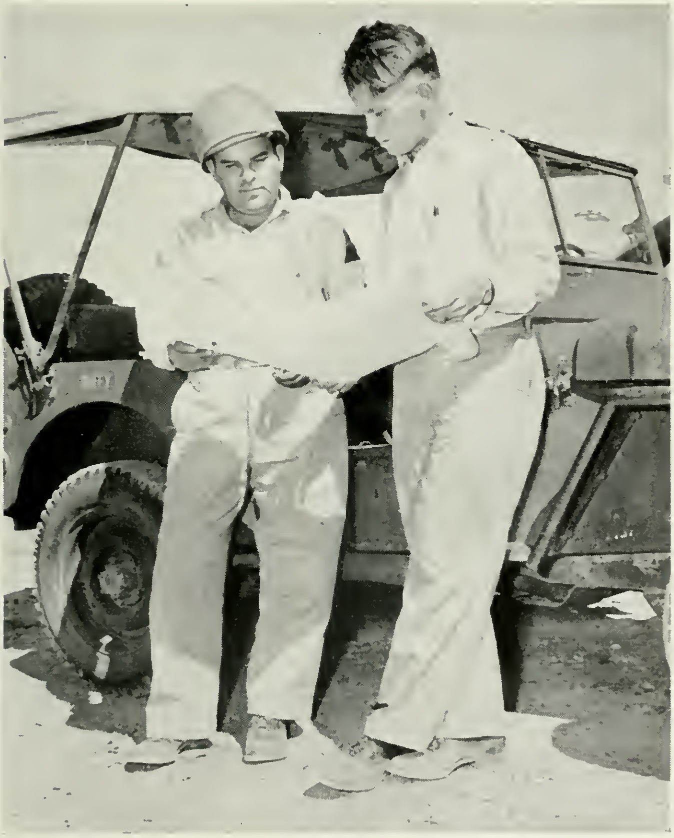
SHELTERS for outdoor telephone booths at Army camps were built to give some protection against the intensity of desert weather

A "PUBLIC TELEPHONE" trailer was used at times in various localities to provide or supplement service for the men in camps



Another phase of the project was the construction of many difficult telephone lines, handled by a selected crew of the Southern California Telephone Company. This work included a 65-mile aerial cable, 40 miles of underground cable, and hundreds of miles of open wire. Many of these new facilities were placed on poles of the two transcontinental lines traversing the region, but many miles of new poles were also set.

In the midsummer heat, the workers donned heavy gloves to handle blistering-hot tools and wires. Everybody wore dark glasses. Salt tablets were taken to maintain balanced body chemistry. The supreme test came in September, when the crews dropped everything to do a special piece of work for the Signal Corps, just before the first large-scale maneuvers. Some 170 route miles of telephone facilities had to be constructed by and for the Army throughout the training area. Fifty-three miles of pole line were constructed by the Army and 117 miles by the telephone company.



A Signal Corps officer and a telephone company construction superintendent review the day's work. During much of the desert job, telephone men and Army men worked side by side

The three hottest weeks of the year saw the telephone men working ten hours a day, in deep sand navigable only by tanks and half-tracks, and through mountains where the holes for setting poles frequently required dynamite blasting. The crews strung 1,400 circuit miles of wire, set 1,000 poles, and installed 1,500 crossarms.

Maximum use was made of carrier systems to conserve copper. At Whitewater, for example, carrier equipment was increased 300 percent. Soon the station had 20 repeatermen, as compared with 12 before the rush began. The heavy traffic also created an immediate need for women to operate new toll board positions. About 115 operators were required. Women throughout the Southern California Company territory volunteered for the assignment and were stationed at Whitewater, Blythe, and Needles.

The typical Army division camp in the desert was of the "rag" variety, consisting of tents—and no improvements. The soldiers lived a life duplicating the conditions they would find overseas. At any given time, there were more than 100,000 troops to direct, transport, hospitalize, feed and clothe independently of normal supply channels; for the training was

An Army jeep accompanies these telephone trucks with their reels of wire on the basis of actual war conditions, thousands of miles from home. Wire communications were essential in effecting coördination.

The wire communications were essentially a private line network principally for intra-communication in the desert. While the extent of the network varied from week to week, it was normally composed of about 3,000 miles of Bell System channels and some 2,000 miles of Army circuits. There were 100 long haul circuits, all interconnectable. Paralleling the telephone network connecting several Army locations were several networks serving many private-line teletypewriters. Augmenting other means of communication with the outside world, the Army used several teletypewriter exchange services.

The maneuvers called for most unusual telephone arrangements, and on short notice. Frequently a complete rearrangement of circuits had to be made in less than eight hours. It was not unusual to establish new circuits and reroute existing circuits within the hour. In the "free" maneuvers, where troops in the field operated on battle problems without

A telephone construction camp in the Army maneuver area of the California desert outside direction, the telephone company provided camp telephone managers to assist Corps Signal Officers for each "side" in the battle. These telephone men moved with the Army in the field.

Throughout the desert activity, the question of "How many public telephones are needed?" was always current, but the real question was, "Can we furnish any at all?" Normally, 300 public telephones would not have been considered too many. But only by using the utmost ingenuity were the company's camp telephone managers able to establish 50 to 70 stations for the entire desert area.

This sparseness of public telephones was due to the fact that the circuits were required for Army calls. Out of 33 talking channels on lines between Camp Young and Iron Mountain, for example, only three were available for personal calls. And along this line during the summer of 1943 there were 60,000 men waiting to call outside. It was arranged to increase the number of circuits available for soldiers' personal use by routing all calls through the Army switchboards, so that when

THEIR day's work completed at the Whitewater toll office at the edge of the desert, these operators are being taken to a hotel at Banning leased for dormitory purposes official calls slacked off, the men could place calls direct with the long distance operators. By this means, a camp having three to six administrative lines could increase the number of public telephones by that amount. At Camp Coxcomb, with 20,000 men, located 75 miles from the nearest town, two public telephones handled 1,000 calls in a month. A trailer installation elsewhere handled 6,000 calls in two months. This was typical.

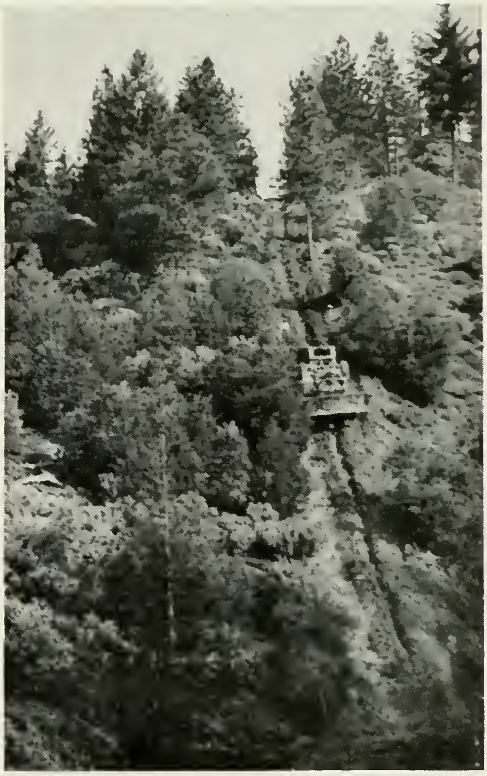
THERE WERE a lot of "headaches" in keeping the public service operating smoothly, but the telephone people did their best, and, with the cooperation of the Signal Corps, turned out a fine piece of work. The desert heat caused unusual service problems. Handkerchiefs had to be used to hold the receiver. There was no shade for booths, and they rested on sizzling ground. There were no long conversations! The paint on one batch of booths was ruined by the heat within 24 hours after arrival. Lean-to shelters were built to shade the booths, shelter walls erected against desert blasts, and floors installed. With these improvements, a man could wait or telephone without either frying or freezing.

Once, when telephone men went by truck to recover two booths from what was reported to be an abandoned camp, they found another Army outfit had moved in. The men were using the booths as prized shower stalls.

Today, a majority of the desert locations which were so active in the early days of the war have returned to wilderness. The entire telephone building at Blythe was recently dismantled and moved, switchboard and all, over 200 miles to Chula Vista, near San Diego, where it is again a "hot spot" of war calls.

Installing the TC Cable

THE THIRD big job was the Pacific Company's part of the transcontinental cable,* installation of which was undertaken to provide more circuits between the east and west coasts in anticipation of the possibility of



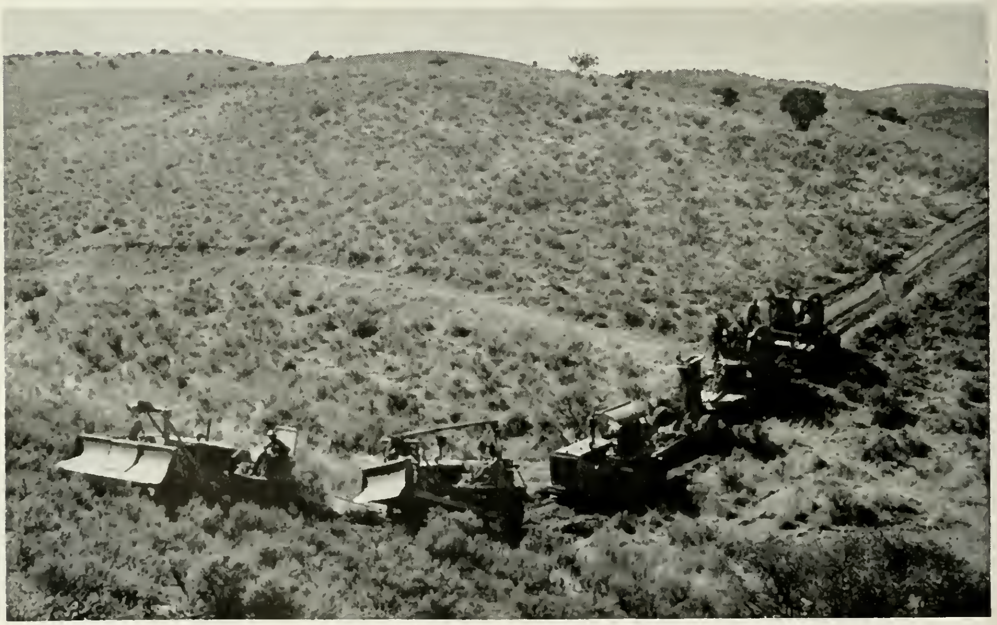
TRACTOR and rooter clear a furrow for the transcontinental cable up a steep hill

---

* See "Engineering the Transcontinental Telephone Cable," MAGAZINE, November 1941.

CLEARING the right of way for the transcontinental cable went ahead in all weathers

THE Pacific Company's cable train plows in the cable west of Wendover, Utah



war with Japan. The company, in coöperation with the Long Lines Department and other Bell System Companies, started this cable work in the autumn of 1940. The cable was open for service in December, 1942. The Pacific Company's and Bell Company of Nevada's share in gross construction amounted to $7,300,000 and involved 500,000 man-hours of telephone company work.

Mud fought the progress of the cable train in some localities

The combined teamwork of the Bell System—the O. & E. staff of the A. T. & T. Company, the manufacturing and supply capacity of Western Electric, and the coöperation of other Associated Companies—enabled the Pacific Company to muster the needed material and personnel to complete the jobs in the shortest possible time.

Trenching by hand was sometimes necessary in rocky terrain

The Pace Accelerates

Huge population shifts within the coastal territory, as well as from other parts of the country, created tremendous demands for service, over and above military and war industry demands. As of May 1, 1945, the Pacific Company had 256,140 unfilled applications for main telephones; and 187 central offices designed to serve 1,000 or more main telephones had reached their capacities—or 50 percent of the total of such central offices which serve about 96 percent of the telephones in the Pacific Company system.

Splicers of the Pacific Company and Long Lines make the final splices in the transcontinental cable at the Nevada-Utah state line

The acceleration of the war in the Pacific theater of operation continues. Big installations are still very much in the present tense. For example, the Kaiser steel mill at Fontana, California, which was set down in the midst of orange orchards in 1942, is now said to be the world's largest producer of heavy ammunition. A large Navy project is under construction involving an investment of $30,000,000 and employing almost 9,000 people.

With V–E Day, the entire might of America's war effort turned westward, and the Pacific Coast accelerated its already fast pace. It follows that the telephone company will meet increased service demands. The coast, with 40 air bases suitable for training, is a logical location for the re-assembly of air forces from the European theater. Shipments of men and materials will logically increase from coast ports, staging areas, and embarkation points.

The telephone company's construction program for 1945 contemplates the installation of central office equipment, private branch exchange switchboards, and other equipment on subscribers' premises; and exchange and toll lines to serve the growing needs within our territory to the extent that material and manpower are available.

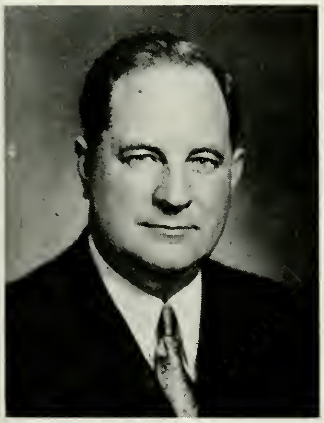
These are some of the highlights of the situation on the Pacific Coast. The telephone company has a definite problem, calling for continuous and effective action in promptly providing necessary facilities and services. In addition to the materials and manpower necessary for carrying out the required construction to provide for the growth of this business, additional traffic operating employees are needed to handle the increasing number of local and toll and long distance calls.

The provision of the necessary additional facilities and employees will be a stupendous task. In all of the forward march, shoulder to shoulder, the Pacific Company and its people have every faith and confidence that, through the aid and assistance of the centralized staff and the other Associated Companies, this fine record will be maintained.

Who's Who & What's What *in This Issue*

THE willing, courteous, and effective assistance of many members of the Army and Navy, of all ranks, is evident in the section of this issue dealing with *Electrical Communications in World-wide Warfare.* Without their aid and counsel the necessary information could not have been compiled nor the photographs obtained. And since it is not practicable to make acknowledgment here to so many individuals, the editors express in this fashion their sincere thanks and appreciation to all those in the Services whose help has made possible so unusual a feature in these pages.

Neither is it feasible to give "credits" individually for so many photographs. They were secured—with a few exceptions—from the Army's Bureau of Public Relations, the Signal Corps, the Army Air Forces, the Navy, the Marine Corps, and the Coast Guard. They give abundant evidence of the splendid work of the Services'



JAMES J. PILLIOD

HAROLD L. RYAN

GEORGE H. JESS

photographic sections in making a pictorial record of every aspect of this war.

It is a startling picture of long distance service in the not too remote future which James J. Pilliod and Harold L. Ryan paint. As assistant chief engineer, and assistant vice president in charge of the traffic division, respectively, of the A. T. & T. Company's Department of Operation and Engineering, they are in key positions to discuss the equipment and methods which will make operator toll dialing possible on a nation-wide basis, and the improvements in service which will come with it.

Starting with the Long Lines Department in 1908, Mr. Pilliod had become by 1914 its division plant engineer in Chicago. In New York since 1918, he had been successively the Department's engineer of transmission, engineer, and general manage before transferring to his present post in 1943. Mr. Ryan's Bell System career, entirely devoted to work in traffic, began with the New England Telephone and Telegraph Company in 1920. Transferred to the O. & E. Department of A. T. & T. in 1927, he was traffic results engineer from 1940 until his present appointment earlier this year.

The problems which the war brought to telephone people on the Pacific Coast are vividly set forth by George H. Jess. Beginning with the Pacific Telephone and Telegraph Company in 1910 as a splicer's helper, he is now the company's operating vice president. In the intervening 35 years his experience has ranged from lineman to sales representative to general commercial manager and, just previous to election to his present position in 1943, assistant vice president in charge of operating matters and vice president and chief of staff.

Tonight in Maine a fisherman is listening to the same music you are hearing. In Wisconsin a farmer tuned in right after supper and is hearing this program. A banker and his children are listening in Texas. And on the West Coast a wounded seaman, just back from the Pacific, will hear it on a bedside radio in a hospital.

For one of the things radio has done is to bring the beauty and solace of the world's great music to all people in all places. Here in America the people in little, out-of-the-way spots can hear and enjoy the performance of distinguished artists the same as those in great metropolitan centers. There is no remoteness any longer.

Radio and telephony combine to make this possible. Many radio stations are linked together for a network program such as this—linked by telephone wires especially designed for the transmission of music, so that it may be sent to you with all the clarity and fidelity of tone with which it is produced by the great artists who, week after week, appear in our studio.

We of the Bell System consider it a special privilege, in times like these, to be able to send you these great artists and this fine music. May it bring to all of you a large measure of enjoyment.

From a "Telephone Hour" radio broadcast

ume XXIV · Number Three Autumn 1945

Bell Telephone MAGAZINE

Public Library

Reasonable Earnings to Insure the Best Service · Leroy A. Wilson

Western Electric Tackles the Peace-time Emergency · Walter M. Reynolds

That First Call Home · T. Hunt Clark

Guardians of the Skyways · H. C. Lauderback

The Messages Go Through in Many Ways · H. I. Romnes

erican Telephone & Telegraph Company · New York

Bell Telephone *Magazine*

Autumn 1945

Reasonable Earnings to Insure the Best Service,
Leroy A. Wilson, 137

Western Electric Tackles the Peace-time Emergency,
Walter M. Reynolds, 158

That First Call Home, *T. Hunt Clark,* 174

Guardians of the Skyways, *H. C. Lauderback,* 188

The Messages Go Through in Many Ways,
H. I. Romnes, 203

"The ideal and aim of the American Telephone and Telegraph Company and its Associated Companies is a telephone service for the nation, free, so far as humanly possible, from imperfections, errors, or delays, and enabling anyone anywhere to pick up a telephone and talk to anyone else anywhere else, clearly, quickly and at a reasonable cost."

A Medium of Suggestion & a Record of Progress

Published for the supervisory forces of the Bell System by the Information Department of
AMERICAN TELEPHONE AND TELEGRAPH CO., *195 Broadway, New York 7, N. Y.*
WALTER S. GIFFORD, *President;* ROBERT H. STRAHAN, *Secretary;* DONALD R. BELCHER, *Treasurer*

Who's Who & What's What *in This Issue*

"Bell System post-war plans constitute a dynamic, forward-looking program. They can be carried out if earnings are maintained sufficiently high to attract from investors the money to build the new improved plant that will be needed. This will make plenty of jobs, better service, and more service. The people who provide the service, the people who use it, and the public authorities who regulate it have coöperated in the past to make possible the tremendous improvements already accomplished, and there is every reason to believe that they will continue to make possible reasonable earnings which will insure the best service in the future." So may be summarized the article by Leroy A. Wilson, A. T. & T. Vice President charged with responsibility for business research and studies of Bell System revenue requirements. Entering the Indiana Bell Telephone Company as a traffic student in 1922, he was a district traffic chief and a district traffic superintendent there until 1929. In that year he joined the traffic division of the Department of Operation and Engineering of A. T. & T. as an engineer, later becoming a group head in that division. In 1939 he transferred to the commerical division of the O. & E. Department, where he was successively directory engineer, rate engineer, commercial engineer, and assistant vice president until assuming his present office a year ago.

Several days spent in the stimulating atmosphere and humming tempo of Western Electric's Hawthorne Works so impressed Walter M. Reynolds with the zeal and determination which pervade that plant that he returned to New York to write this issue's fast-moving account of what is involved in the change from making special military materiél under war pressure to making telephone equipment under the scarcely less urgent pressure of the Bell System's present peace-time needs. After five years as a newspaper reporter, Mr. Reynolds joined the Public Relations Department of the Bell Telephone Company

Mr. Wilson

Mr. Reynolds

Mr. Clark

Mr. Lauderback

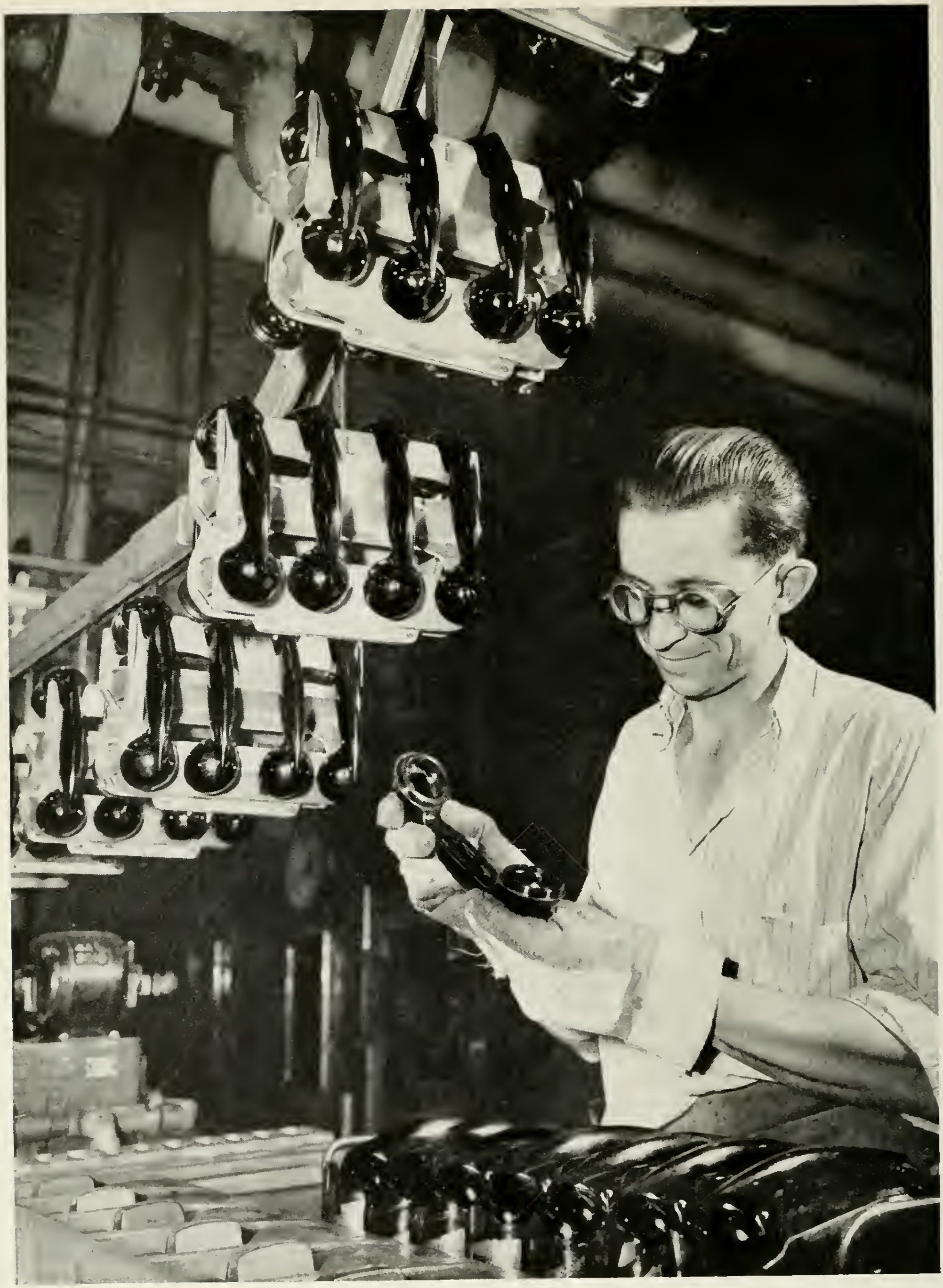
Mr. Romnes

of Pennsylvania in 1929 as assistant editor of *The Telephone News.* A year later he became that publication's editor, was made general information supervisor in 1936, and was appointed general information manager in 1941. He transferred to the A. T. & T. Company in 1944, where he is information manager in the Information Department.

Ever since the Selective Service and Training Act of 1940 first began to fill Army camps with young men in khaki, the Bell System has done everything within its power to provide convenient telephone service for members of the armed forces. It has been a big job, and by no means easy of accomplishment; but it has been very much worth doing, as a great many notes of thanks from the men and their relatives bear witness. Now the end is in sight, and T. Hunt Clark describes scenes from the last act: the men and women just back from overseas enabled to talk with loved ones as soon as possible after they set foot in the U. S. A. An officer in two wars, Mr. Clark spent the years between them in the commercial engineering division of the New York Telephone Company, as secretary to President Walter S. Gifford of the A. T. & T. Co., and in the sales and servicing section of the commercial division of the Department of Operation and Engineering of A. T. & T. His work on communications for Civilian Defense led early in 1943 to a commission as Major, AUS, and appointment as Chief of the Control and Communications Section of the National Office of Civilian Defense in Washington. Subsequently he was an instructor at the Army Industrial College until his discharge last February. Back in the sales and servicing section, he is now working on public telephone service for the armed forces—including, of course, service at Disposition Centers.

Using nearly 150,000 miles of private telephone and teletypewriter lines, the Civil Aeronautics Administration is one of the Bell System's biggest customers. Yet relatively few people, except those directly concerned, know much about the functions of the C. A. A. nor about the importance of its communication system in administering the Federal airways and controlling the planes which use them. These matters H. C. Lauderback discusses from a background of 15 years of close association with the C. A. A., during which time he has—among other things—recommended equipment and assisted in designing circuit networks to meet its special requirements. Starting in the Engineering Department of the Southwestern Bell Telephone Company in Kansas City in 1911, Mr. Lauderback became toll traffic engineer two years later.

(*Continued on page 187*)



Good news! Telephones are again rolling off the Western Electric Company's production lines, to break one of the bottle-necks in civilian communication equipment which was created when practically all of Western Electric's great productive capacity went to war. It is an ironic circumstance that the moulder who holds the handset shell in this picture has been waiting for many months for a telephone. See the article beginning on page 158

Adequate Earnings Are Necessary to Secure the Capital Required for the Future Expansion of This Business to Meet the Nation's Increasing Needs for Service

Reasonable Earnings to Insure the Best Service

Leroy A. Wilson

THE HISTORY of the telephone in America is a most remarkable one. In dynamic American fashion there has been developed in this country the finest communication system in the world. This system is enormous in size, but bigness is only one of its characteristics. It is also one of the most delicately balanced physical structures on the face of the earth. Each part is finely fashioned in itself and finely tuned to work in harmony with billions of other parts. Only the best in design, manufacture, and maintenance is good enough; for a fleck of dust in San Diego can trouble an ear in Portland, Maine. Similarly, only the best in human operation will properly serve the telephone's purpose; a careless act may deeply affect a human life.

There are many reasons why this great system works so well and is so universally used. You will find one reason in "the voice with a smile" and another in the complicated equations of the research physicist. But there is a fundamental reason which underlies all the others. It is that the people who provide the service, the people who use it, and the public authorities entrusted with regulation of its over-all operation have generally coöperated in the effort to make telephone service always better tomorrow than it is today. The progress of the telephone in America has sprung from the initiative, the spirit of fair play, and the common sense of the American people. These have encouraged and nourished a development which the rest of the world looks at with admiration. Without them, the tremendous accomplishments in telephone service would have been impossible.

The public looks forward to the same kind of progress in the future that has been achieved in the past, and for the same reasons. The opportunity for progress is enormous. The physical means and human skill are at hand to provide far more and better telephone service than ever before. New tools and new techniques only await practical application. Bell System people know how to turn the promise into performance, and they also know from experience that the key to success is full understanding of the whole process by all concerned—not only by telephone employees, but also by the public and by government authorities responsible for regulating telephone enterprise in the public interest.

Progress since 1920

WHEN TALKING about progress it is well to be specific. In the last 25 years the total amount of telephone service rendered by the Bell System increased several times over. The speed and quality of the service improved enormously. The cost to the public per unit of service went down. Wage rates of telephone employees went up. To make all this possible, hundreds of thousands of people bought shares in the Bell System. Others lent the System their dollars. All this money, totalling more than $2½ billions additional since 1920 alone, was used to build telephone plant. When war came, the vast telephone system which had been built proved an invaluable asset in helping to speed victory.

This is a success story. It couldn't be called that if the goal of the Bell System had been simply to make money. But the earning of money,

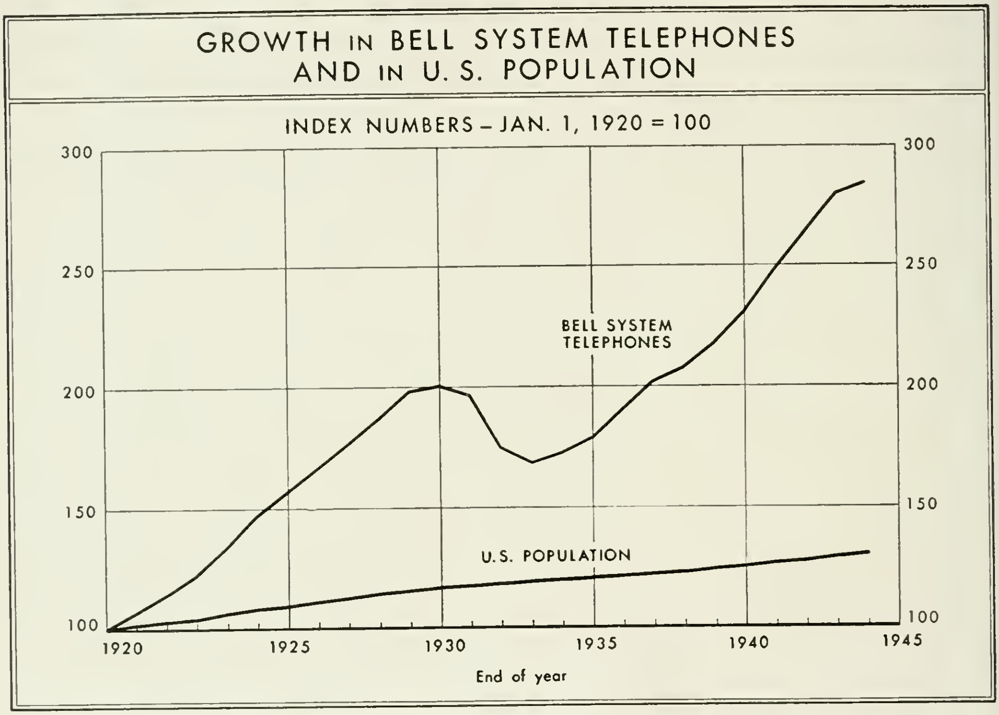


FIGURE 1

although essential to successful operation, was not the primary objective. The objective was to provide a continuously expanding and improving service at the lowest possible cost. Earnings were the essential means required to make sure that investors would be attracted by the prospect of a steady return on a safe investment, and would provide the money needed to build the plant to give the service. The System voluntarily and publicly stated that it did not want earnings higher than were needed to accomplish that result. The general public, and the state and federal commissions which regulate the telephone business, saw that words were backed by action, and permitted the System to earn the money it required to expand and improve its service. It was a coöperative undertaking, based on the understanding and good faith of all concerned, and great success came of it.

In those 25 years beginning in 1920, the number of Bell telephones nearly tripled while the population gained only about 30 percent (Fig. 1). All classes of telephone service came into wider use—local, toll and long distance calls, business and residence service, main and extension telephones, and private branch exchange service (Fig. 2). The average daily number of conversations handled by the System went up from 33 million to more than 85 million and conversations per person increased from about 160 to 280 a year. Inter-city telephone messages shot up from 360 million to more

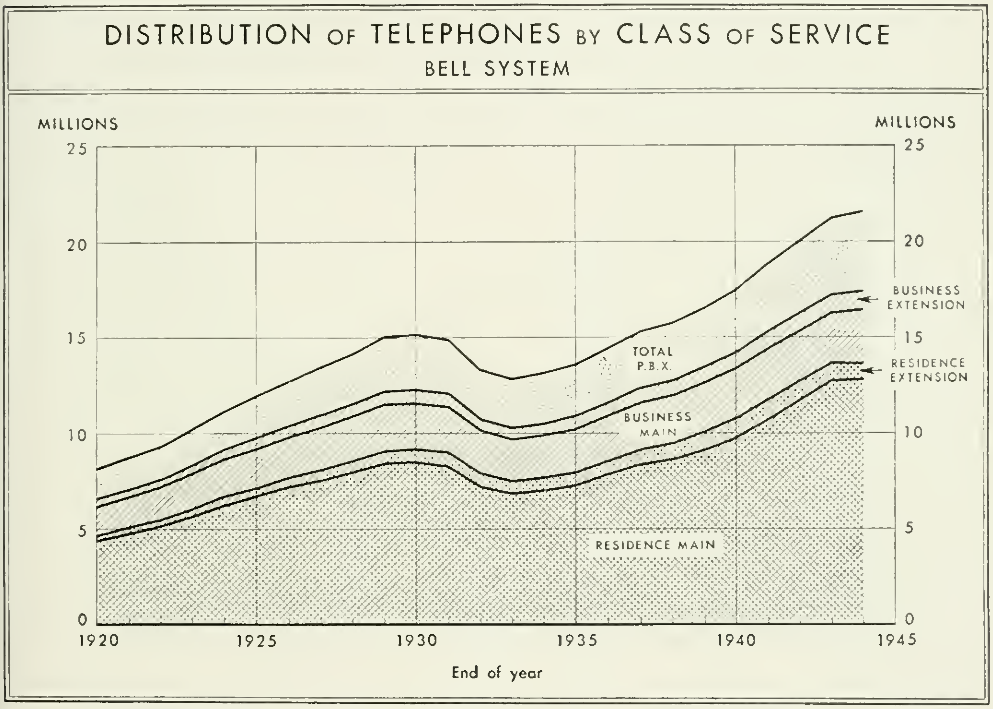


FIGURE 2

than 1500 million a year (Fig. 3). Over the routes of the A. T. & T. Long Lines Department the number of conversations increased seven-fold, from 25 million a year to about 195 million (Fig. 4). Overseas radio telephone service was introduced in 1927 and subsequently extended to more than 75 countries and territories throughout the world. Service to ships, which began in 1930, has also experienced a rapid growth (Fig. 5.)

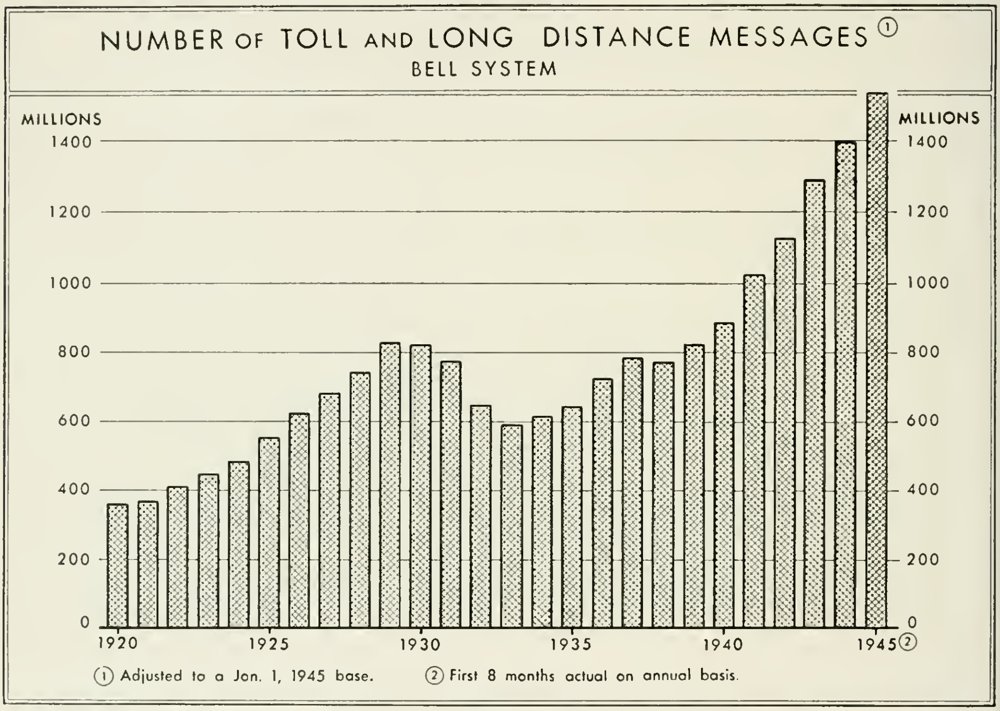


Figure 3

While quantity of service was increasing, so was the quality continuously improving. Fast, accurate dial service was introduced and extended to approximately two-thirds of all Bell telephones. As this was being done, the performance of the equipment itself was improved and coöperative efforts by the companies and their customers brought about a steadily increasing understanding of the correct way to use the dial telephone. Since 1925, the rate of cut-offs, wrong numbers, and interruptions in dial offices has been reduced by two-thirds, or from 2.4 percent to less than 1 percent of total calls. Since each one-tenth of 1 percent improvement affects about 20 million calls a year, the over-all betterment is measured in hundreds of millions of calls annually.

Similar improvement has been made in the handling of additional hundreds of millions of local calls at manual switchboards. Today, also, information operators handle calls on the average one-third faster than 20 years ago.

The quality of toll and long distance telephone service has been vastly improved. The average time for completing calls in toll offices in 1920 was 14 minutes. In 1940 it was one-tenth of that. In the same period the proportion of these calls requiring more than 10 minutes to complete was cut from 40 percent to practically zero. "No hang up" long distance service climbed from about 10 percent to more than 90 percent of all calls, and transmission quality has been substantially bettered. In 1920, carrying on the average toll conversation was like conversing with a person in a quiet open field at a distance of approximately 80 feet. Now the equivalent distance is about 15 feet.

In the war period some of these gains were partly lost because of the overloading of facilities; but even at the peak of war activity, toll and long distance service was far more swift and accurate than in the years following World War I, and all war demands were met fully and promptly.

Twenty-five years ago Bell System customers reported trouble with their service on the average about twice a year. Now the average is about once every two years. Moreover, with improvements in procedures for clearing troubles, the proportion of out-of-service troubles not cleared the same day as reported is less than one-fourth of what it used to be. Bell System plant and maintenance have so improved that today troubles occur in dial central office equipment only one-sixth as often as they used

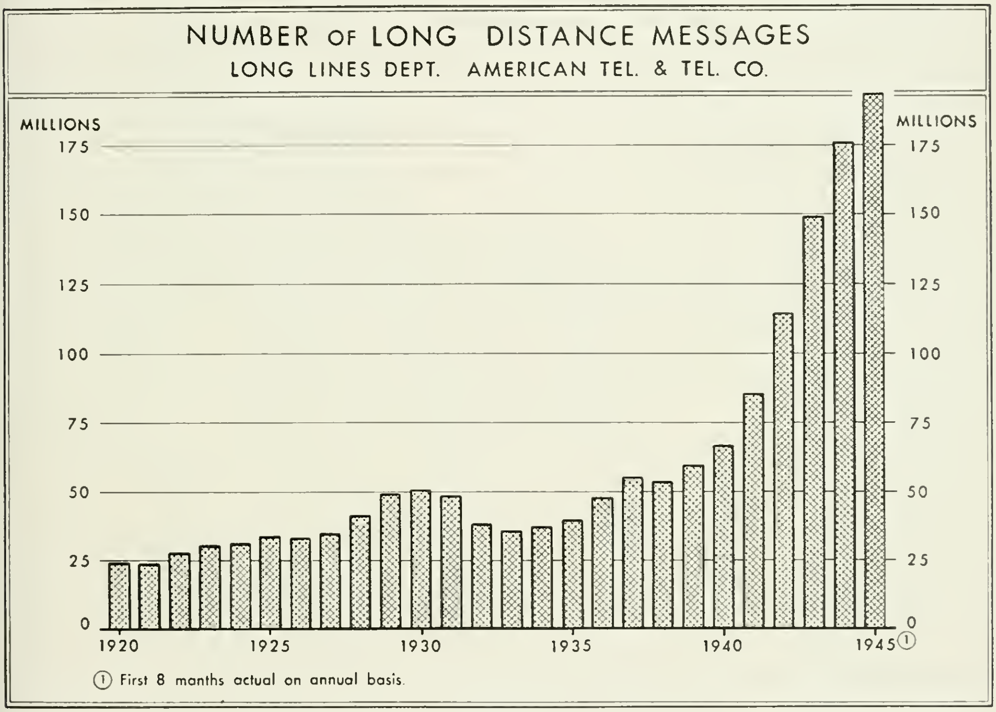


FIGURE 4

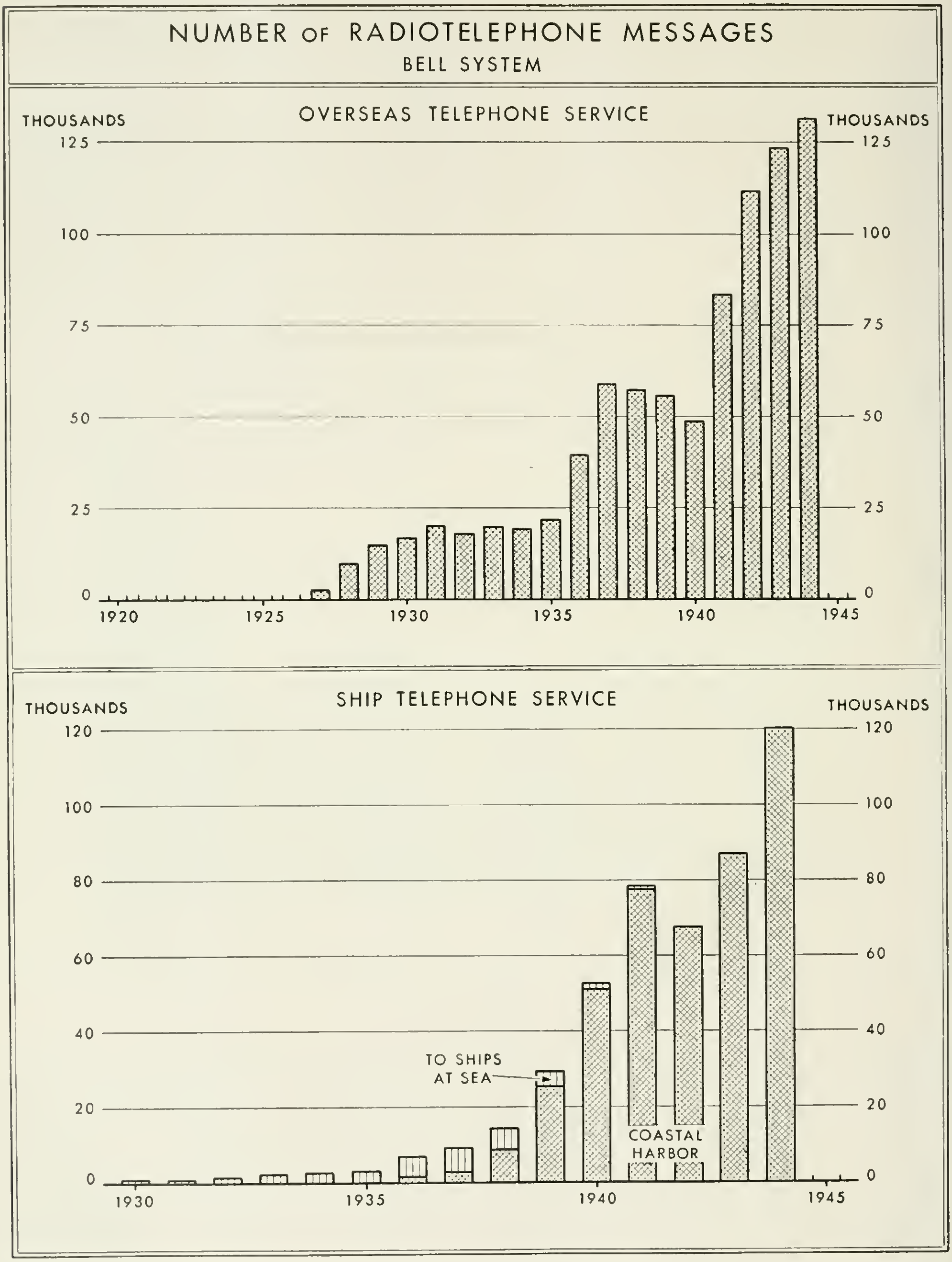

NUMBER OF RADIOTELEPHONE MESSAGES
BELL SYSTEM
OVERSEAS TELEPHONE SERVICE
THOUSANDS
125
100
75
50
25
0
1920
1925
1930
1935
1940
1945
SHIP TELEPHONE SERVICE
THOUSANDS
120
100
80
60
40
20
0
TO SHIPS AT SEA
COASTAL HARBOR
1930
1935
1940
1945

FIGURE 5

to, and in outside plant less than half as often. Furthermore, whereas in 1920 relatively few service installations were being made on the same day the order was received, the next business day, or some other day the customer preferred, by the time of Pearl Harbor more than 80 percent of all installations were being so made.

Better Service at Less Cost

So reads the record. Service is faster, more accurate, more dependable, more courteous as well as many times more extensive.

It is also "more for the money."

Today telephone service is being furnished at relatively less cost to the user than at any time in history.

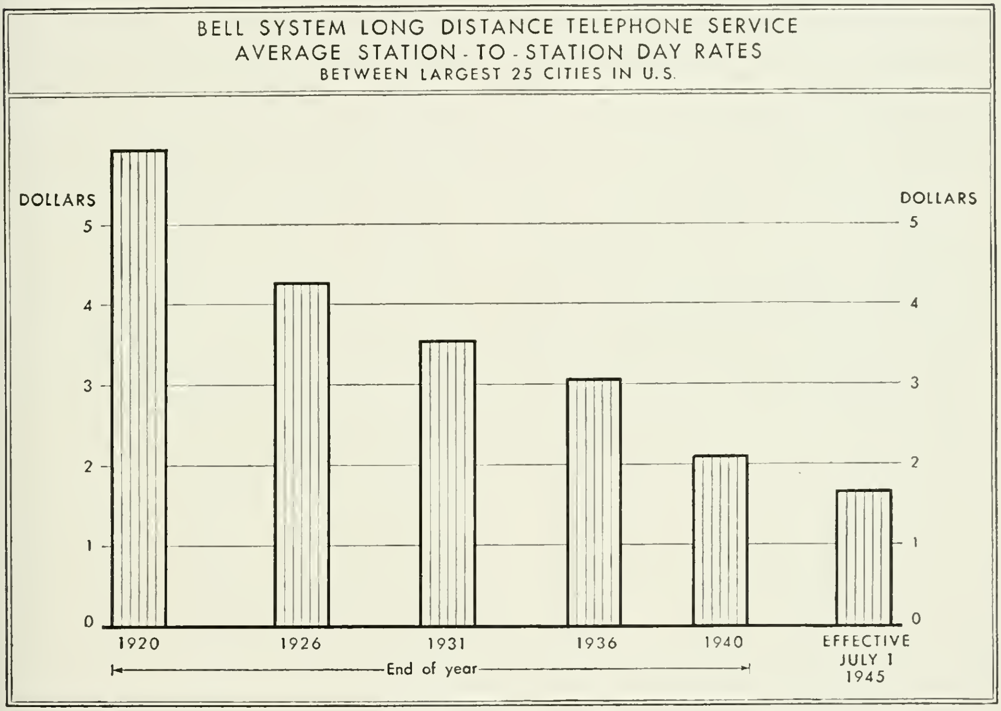


FIGURE 6

That is not all. Service to customers at business offices has immeasurably improved. Customers' needs are met more promptly and with fewer errors. Also, employees have greatly improved the over-all "tone" of telephone service; there is better understanding of the customer's problems; and the reasons for company policies and practices are better and more fully explained to the customer.

Compared with rates of 25 years ago, Bell System customers are now saving 250 million dollars annually.

Long distance rates are much lower than in 1920. The average station-to-station day rate between the 25 largest cities in the country is down from about $6.00 to less than $1.75 (Fig. 6). The transcontinental day rate for a station-to-station call has been reduced from $16.50 to $2.50.

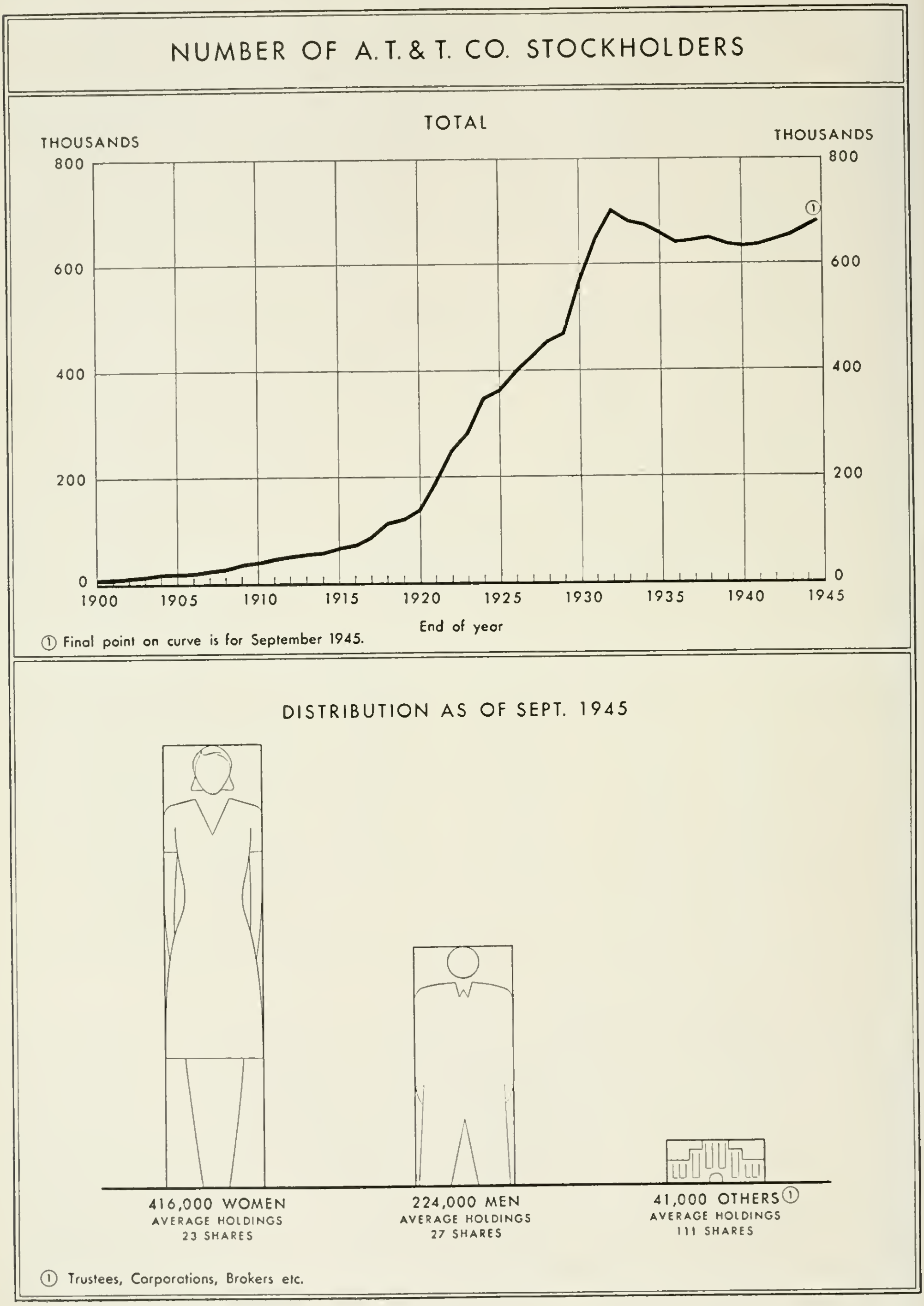

NUMBER OF A.T.&T. CO. STOCKHOLDERS
TOTAL
THOUSANDS
THOUSANDS
800
600
400
200
0
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
①
End of year
① Final point on curve is for September 1945.
DISTRIBUTION AS OF SEPT. 1945
416,000 WOMEN
AVERAGE HOLDINGS
23 SHARES
224,000 MEN
AVERAGE HOLDINGS
27 SHARES
41,000 OTHERS①
AVERAGE HOLDINGS
111 SHARES
① Trustees, Corporations, Brokers etc.

FIGURE 7

Overseas rates have been cut drastically since the service was opened in 1927; for example, a New York-London call which cost $75 in 1927 now costs but $12.

Just as important has been the great increase in the value of local service. One of the principal measures of the value of local telephone service is the number of other telephones in the exchange or area that each customer can call. In the 170 largest U. S. cities served by the Bell System, the average number of telephones the customer can reach by a local call has increased from 30,000 in 1920 to over 80,000 today, and the monthly cost to the residence customer measured by each 1,000 telephones he can reach by a local call has declined 60 percent.

Quality of service has gone up. Over-all cost of service has gone down. These things have taken place together and are related to each other. When service is made better, people want and use more of it. When efficiency is improved, the result is better service *and* lower cost. A telephone that goes "in trouble" only once every two years obviously gives better service than one that gets out of order twice a year. It is also (other things being equal) less costly to maintain. Similarly, a toll call that takes one minute to complete is better service and is less costly than one that takes 10 minutes.

Two things are essential to maintain this process of giving better service at less cost. One is continuous research to develop constantly improving methods and equipment. The other is money from investors with which to build the improved plant that research makes possible. Also, because better service brings public demand for *more* service, more and more plant of steadily improving quality must be built. This means that the Bell System must steadily attract the new capital—the new money from investors—that is needed to build it.

In order to make sure that telephone service will constantly improve, the Bell Telephone Laboratories and the General Department of the A. T. & T. Company are working all the time to develop new devices, better systems, and improved methods. In order to make sure that the new, improved, and expanding plant can be built, money to pay investors an attractive return on their investment must be earned. If they think that their investment is safe and that the return they obtain is attractive, they will put up more money to build the new plant. The new plant, in turn, gives the telephone user more for *his* money. That is the cycle.

What Earnings Are Needed To Continue Progress?

How much, then, does the Bell System need to earn to induce investors to keep on entrusting their money to it? Is it earning enough today? Will the public, and its representatives on regulatory commissions, permit earnings sufficient for tomorrow? It is vital that they should. It is certainly to be expected that they will, for they are as interested as Bell System people in making sure that the communication needs of the nation are served as well as possible.

Now let us look at the Bell System financial set-up and past earnings, and see what they suggest as to what the

System's future earnings need to be.

The money invested in the System increased from about $1⅓ billions in 1920 to a total of more than $4 billions at the end of 1944. Two-thirds of this $4 billions is money belonging to the hundreds of thousands of people who bought stock, becoming part owners in the business. They now number more than 680,000, of whom more than 60 percent are women (Fig. 7). Some 60,000 are Bell System employees. The average number of shares held per stockholder is 29. No stockholder owns as much as one-half of one percent of the stock. More than 200,000 own five shares or less.

The Bell System thus belongs to people in all walks of life in cities, towns, and villages throughout America. The money comes from the savings of the many rather than the wealth of the few. The reason for this is that only the many—that is, hundreds of thousands of small investors—have the money to own such a big business.

The other one-third of the System's $4 billions of capital is borrowed money represented by bonds. So there are two kinds of capital invested in the business—stock money and bond money. On the bond money interest must be paid, while holders of stock must be paid sufficient dividends to keep them interested in buying *new* shares when the System needs more stock money to expand and improve its plant.

Immediately following World War I some 46 percent of the total capital was bond money, but this proportion has been reduced until it now stands at about a third of the total. For this bond money the System pays interest at an average rate of a little more than 3 percent. Some investors—savings banks for example—are generally not authorized to purchase common stocks but can invest in bonds. Still other investors simply prefer bonds. So, in order to tap certain important sources of investment funds to secure the substantial amounts required, the only way to get money from these sources is by borrowing.

Risks of Too Much Debt

However, just as in one's personal affairs, it isn't prudent to borrow too much. If bad times cause a loss in earning power, this may result in failure to earn the interest on the borrowed money. That means loss of credit, and when credit goes smash, like Humpty-Dumpty it is extremely hard to put it together again. The late Joseph B. Eastman, when he was serving as Federal Coördinator of Transportation, said, "Never incur debt unless absolutely necessary. Confine capitalization to common stock, so far as possible, and issue no more than need be of that." He gave this advice out of a lifetime of experience in public service regulation.

Even if the worst never happens, borrowing too much isn't wise. When a company borrows, the risk for the stockholders increases, because they know that all the interest on the bonds must be paid before they can receive any dividends. If a company has borrowed a great deal it may find, when it needs new capital, that nobody wants to buy stock. Then the only thing left to do is to borrow still more money, if it can be done, which of course makes an already bad situation worse.

For such reasons the Bell System has followed the sound policy that borrowed money ought to be kept at a practicable minimum. Deciding exactly what the proportion should be is not an exact science, but a matter of good common sense. However, it is obvious that prudent management should not risk harming a company's credit, with consequent long-term harm to its service, simply because bond money at comparatively low interest rates might be temporarily easy to obtain.

Some other industries have borrowed proportionately more of their capital than the Bell System has; for example, the railroads and the electric utilities.

However, the experience of many of the railroads illustrates the dangers of borrowing, rather than the advantages. During the depression, many of them were unable to earn enough to pay even the interest on their bonds, and a number of important roads went bankrupt. It is worth noting that generally those railroads whose bonds represent only about one-third of their capital or less have been able to earn the interest each year, while many of those which have borrowed more have not.

Power companies also have generally borrowed a higher proportion of their capital than is considered prudent for the Bell System. They have been able to do this without running into the same difficulties many of the railroads have. For one thing, their business fluctuates less sharply than the business of either the railroads or the Bell System. During times of depression, earnings of electric utilities have not fallen off to the same extent as the earnings of telephone companies. This is due in large part to the greater stability of their residence market.

The experience of manufacturing concerns is also of interest in this connection. Reports of the Bureau of Internal Revenue on "Statistics of Income" covering some 80,000 manufacturing corporations show bonds to constitute only about 10 percent of the total capital. This shows that these companies, which are generally subject to sharp fluctuations with the ups and downs of the business cycle, have tended to keep their debt at a minimum.

Earnings Needed on Stock

ASSUMING then that the borrowed part of the System's capital should not represent more than approximately a third of the total, what about the other two-thirds—the stock money? What does the System need to earn on that, in order to get more of it when it is needed?

A reasonable way to start looking for the answer is first to review the financial history of the System. Money invested by stockholders in the Bell System increased from about $700 millions in 1920 to more than $2½ billions in 1944. Most of that money was invested in the 1920s, when the System's average earnings were relatively higher than during any other period in the last 25 years. During the period 1920–1926, which omits the abnormal years 1927–1929, the average earnings on stock money were 9.5 percent. No doubt this earning power of the 1920s was an important factor in inducing people then to put their money into the business.

However, there is no certainty that today the System necessarily has to earn as much as it did in the '20s in order to get the new money it needs for further expansion. Over the long period since 1920 the System has, after all, come through pretty well; it has weathered depression and war; it has enormously improved and increased the service, and its credit is good. During this whole period, including good business years, depression and war years, the System's earnings on the investment of the stockholders in the business have averaged 7.8 percent. That's the *average* for the long period from 1920 to 1944. While some uncertainty exists, it looks as though earnings somewhere between those for the period when the System successfully sold most of the stock (9.5%) and the average for the long period (7.8%) may be sufficient to induce equity investors to entrust more money to it in the future.

Investors themselves have provided a test of the reasonableness of the System's past earnings.

There are two ways in which an A. T. & T. stockholder can buy more stock. One is to buy it on the stock market from another stockholder who wants to sell. The other is to buy it from the Company at the times when the Company offers it for sale.

The first method doesn't provide the Company with additional money to build new plant. The second method does.

But the person who buys stock from the Company wants to feel that

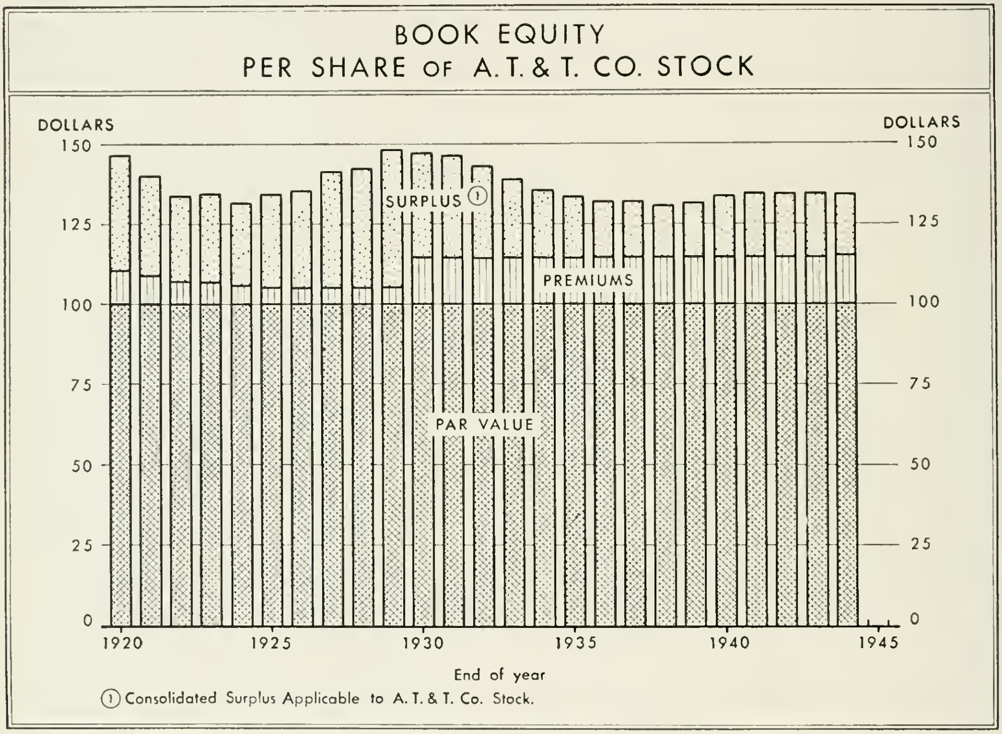


FIGURE 8

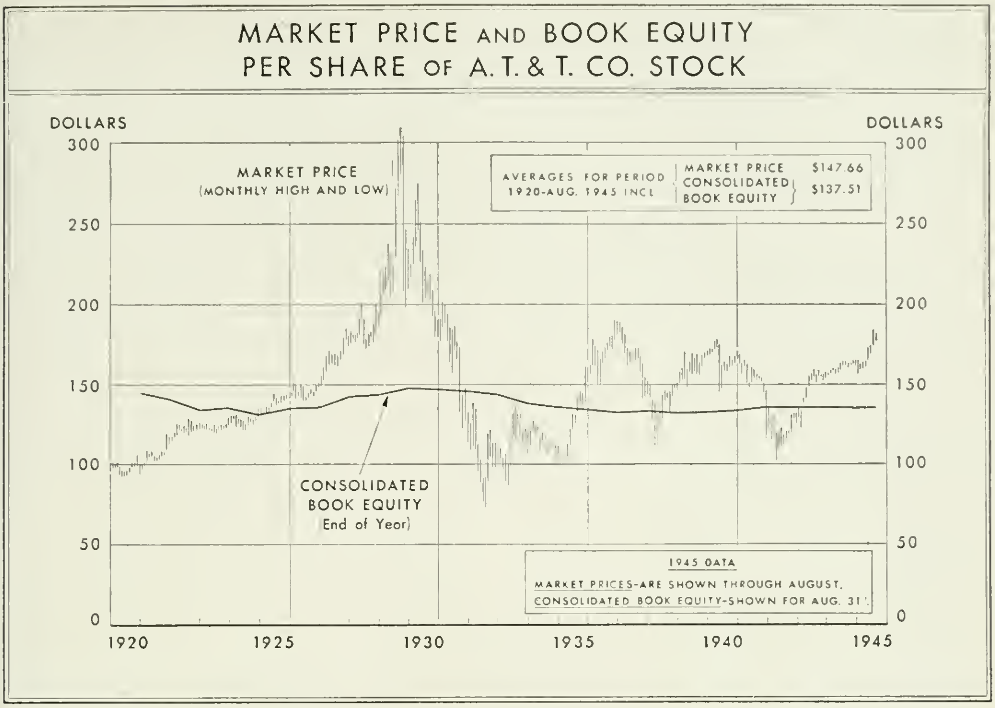
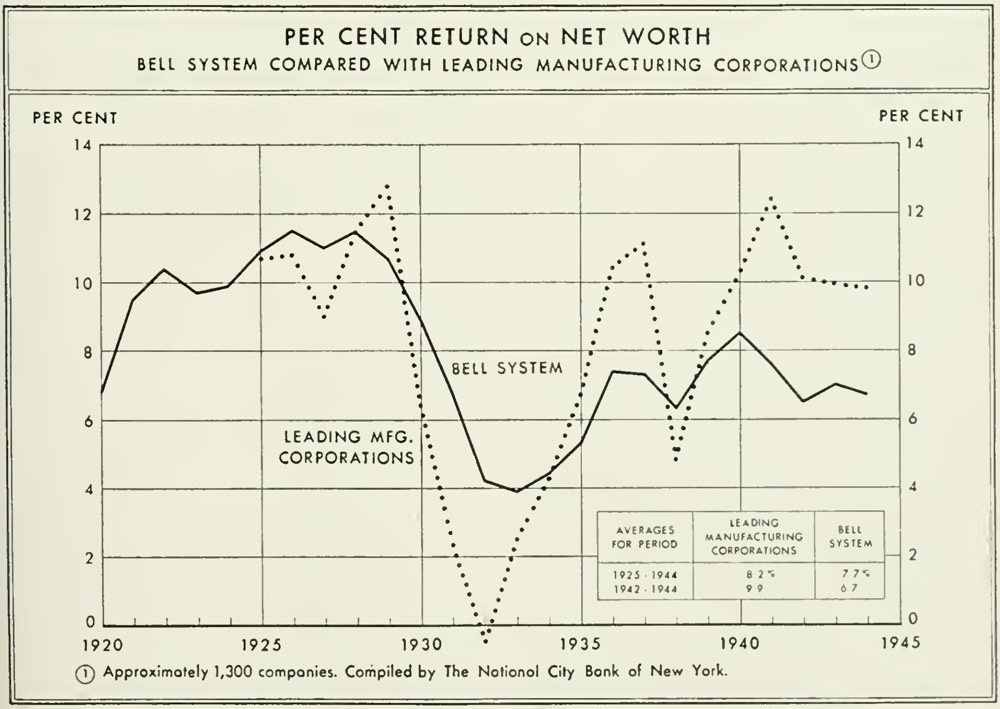


FIGURE 9



AVERAGES FOR PERIOD	LEADING MANUFACTURING CORPORATIONS	BELL SYSTEM
1925 - 1944	8.2%	7.7%
1942 - 1944	9.9	6.7

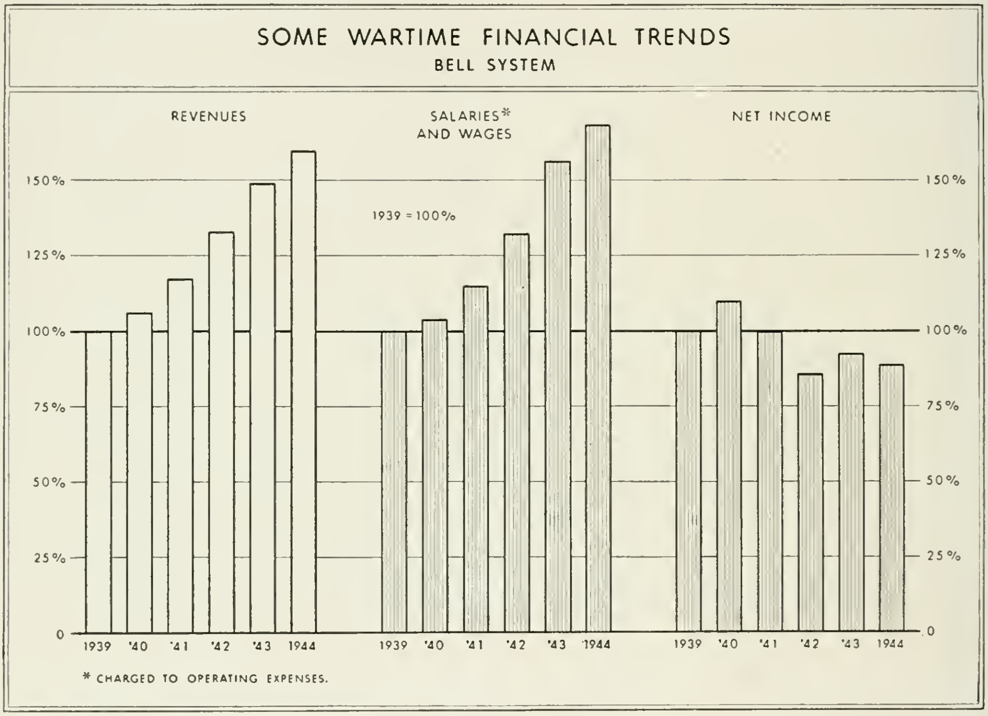
① Approximately 1,300 companies. Compiled by The National City Bank of New York.

FIGURE 10

the integrity of his investment will be maintained. To give him that assurance, the average price he can get on the market ought to be at least somewhat higher than the money represented by his investment in the business.

During the last 25 years, the stockholders' investment in the business has averaged $137.51 per share. This is the average cash per share that the stockholders have actually paid to the A. T. & T. Company, plus the amount of accumulated earnings per share that has not been paid out in dividends but belongs to the stockholders and is part of their investment (Fig. 8).

On the stock market, the price of A. T. & T. stock in the last 25 years has averaged $147.66 a share—about $10 more than the amount per share that the owners of stock actually have invested in the business. This means that the investing public, watching A. T. & T. earnings year after year, has set an average price on the open market just about high enough to give the people who have bought stock from the Company the necessary assurance that in the long run their stock is worth what they have invested in the business (Fig. 9).



* CHARGED TO OPERATING EXPENSES.

Figure 11

Another means of judging what the System's earnings on stock money need to be is to look at the earnings of other companies. Many of them, too, are interested in attracting investors, and the System must compete continuously with them for the investor's dollar. For 20 years The National City Bank of New York has recorded the earnings of approximately 1300 leading manufacturing corporations. In the 20-year period, the earnings of those companies—including both the profitable and the non-profitable concerns—have averaged 8.2 percent on the money invested in them by their stockholders. The comparable average for the Bell System in the same period has been 7.7 percent.

However, the picture in the last three years is quite different. In 1942, 1943, and 1944 the average earnings of this large group of companies rose to 9.9 percent, while Bell System earnings on its stockholders' investment were only 6.7 percent (Fig. 10). This points rather conclusively to the need for increased Bell System earnings in order to compete with other industry to obtain the money for the tremendous construction program which lies ahead.

Incidentally, the System's low earnings in 1942, 1943, and 1944 show definitely that it did not profit from the war; its wartime earnings were, in fact, the lowest since the worst years of the depression. This was in spite of the record volume of business handled (Fig. 11). But today the System must face the fact that it now needs higher earnings to obtain the capital required to meet the demands and opportunities of peace. In times of good business its earnings must be enough to offset the reduced earnings which are inevitable in periods of lower business volumes.

Earnings on Total Capital

To sum up the evidence as to what earnings the System will need:

1. About a third of the capital is now borrowed money and it will be prudent not to increase this proportion of debt if it can be avoided. The average cost of the debt is a little over 3 percent a year and is not likely to go much lower.

2. The other two-thirds of the capital is stockholders' money. At least two-thirds of the *new* capital needed should be obtained by selling more stock. To make sure that the System will be able to interest investors in buying large amounts of new stock, earnings on stock money should at least be somewhere between the earnings of the early '20s and the earnings over the entire span of the past 25 years, say about mid-way between the two, or between 8½ and 9 percent.

3. If one-third of the capital costs a little over 3 percent and two-thirds somewhere between 8½ and 9 percent, then the average earnings required on total capital figure out to be at least from 6½ to 7 percent.

These earnings required to do the job ahead are not high. The System does not ask that they be high—it only wants them to be high enough *to do the job*. And the difference between earnings that are high enough and earnings that are too low is of tremendous importance.

Earnings high enough mean that the Bell System can go forward and improve its service, increase employment, pay good wages, develop further ways and means of increasing the value of the service, and in the long run continue to reduce its cost. Experience proves it. It is because the Bell System as a whole has obtained *enough* money to do its job

PROGRESS OF BELL SYSTEM COAXIAL CABLE PROGRAM

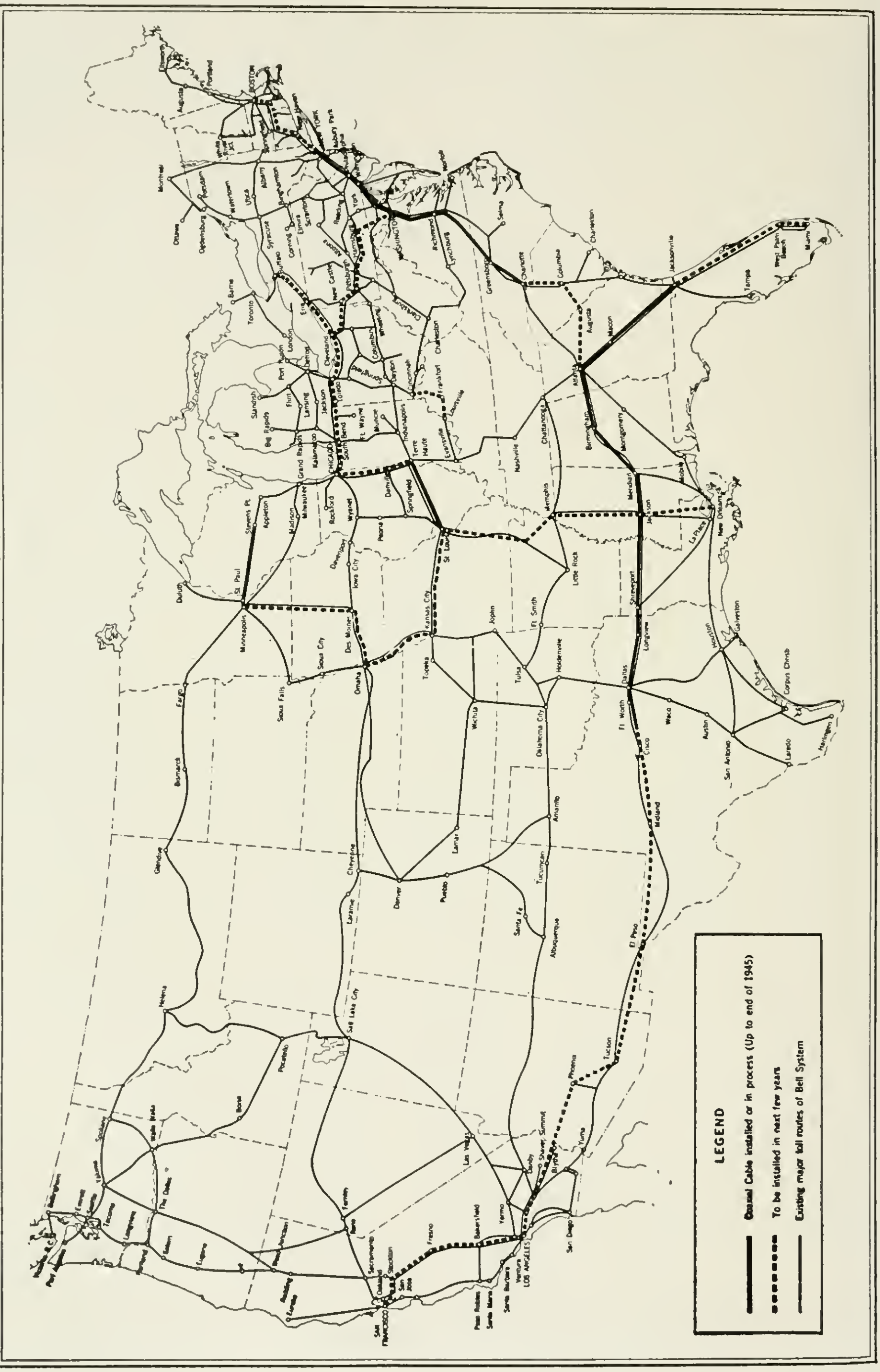


FIGURE 12

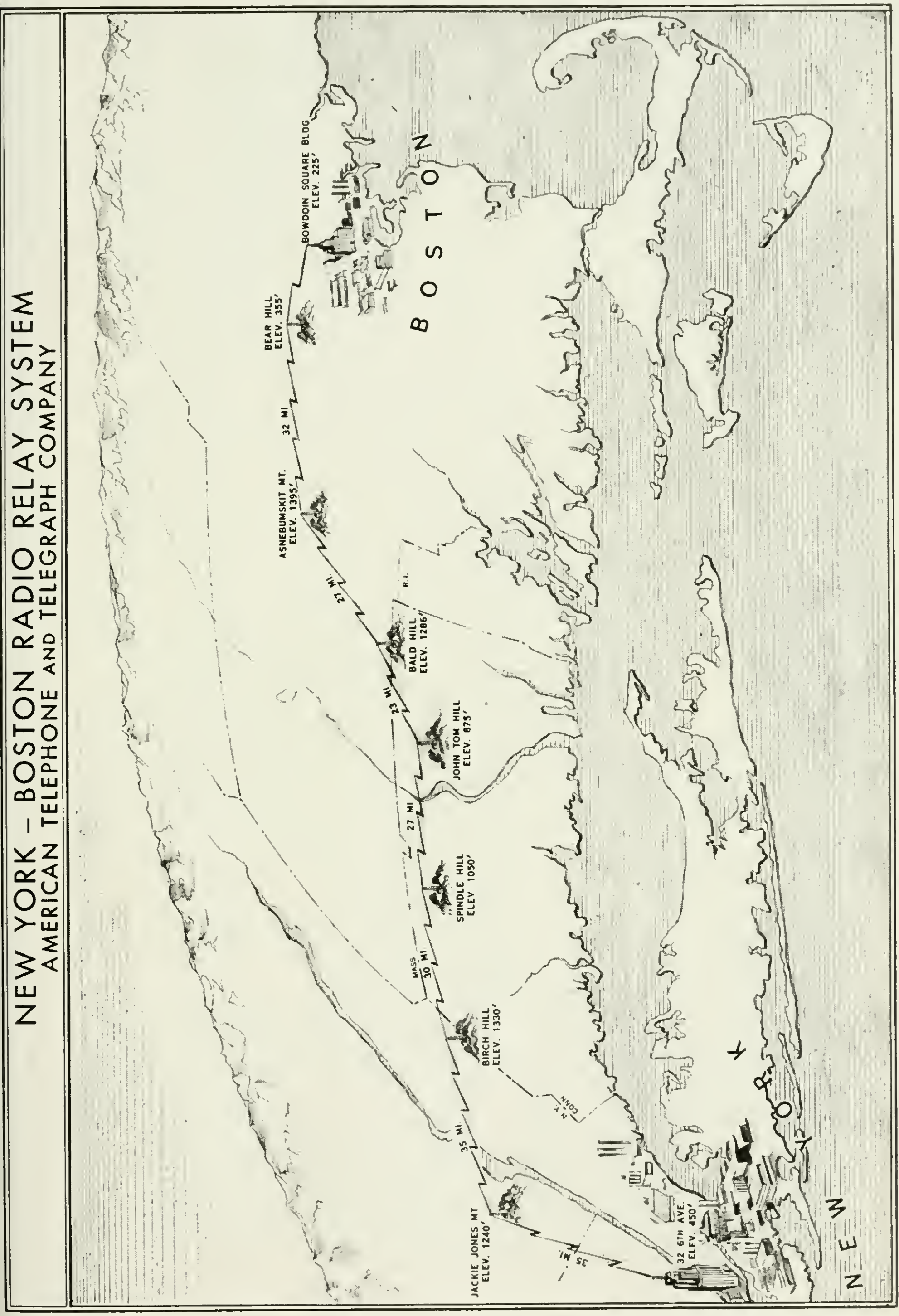

NEW YORK – BOSTON RADIO RELAY SYSTEM
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
JACKIE JONES MT ELEV. 1240'
32 6TH AVE. ELEV. 450'
35 MI.
35 MI.
N.Y. CONN
BIRCH HILL ELEV. 1330'
MASS
30 MI
SPINDLE HILL ELEV 1050'
27 MI
JOHN TOM HILL ELEV. 875'
23 MI
BALD HILL ELEV. 1286'
R.I.
27 MI
ASNEBUMSKIT MT. ELEV. 1395'
32 MI
BEAR HILL ELEV. 355'
BOWDOIN SQUARE BLDG ELEV. 225'
BOSTON
NEW YORK

FIGURE 13

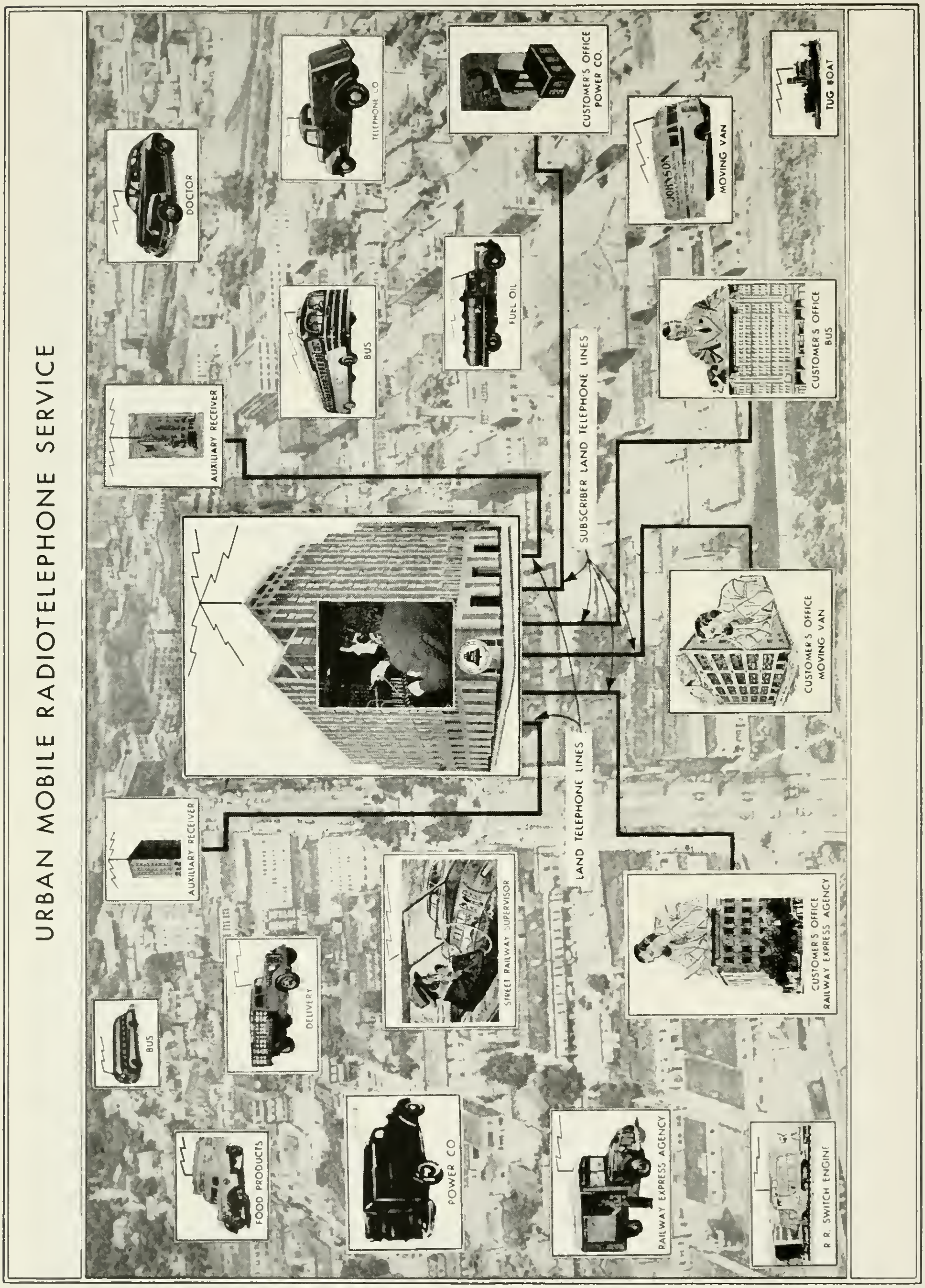

URBAN MOBILE RADIOTELEPHONE SERVICE
DOCTOR
TELEPHONE CO
CUSTOMER'S OFFICE POWER CO.
TUG BOAT
JOHNSON
MOVING VAN
FUEL OIL
BUS
AUXILIARY RECEIVER
SUBSCRIBER LAND TELEPHONE LINES
CUSTOMER'S OFFICE BUS
CUSTOMER'S OFFICE MOVING VAN
LAND TELEPHONE LINES
AUXILIARY RECEIVER
STREET RAILWAY SUPERVISOR
CUSTOMER'S OFFICE RAILWAY EXPRESS AGENCY
BUS
DELIVERY
FOOD PRODUCTS
POWER CO
RAILWAY EXPRESS AGENCY
R. R. SWITCH ENGINE

Figure 14

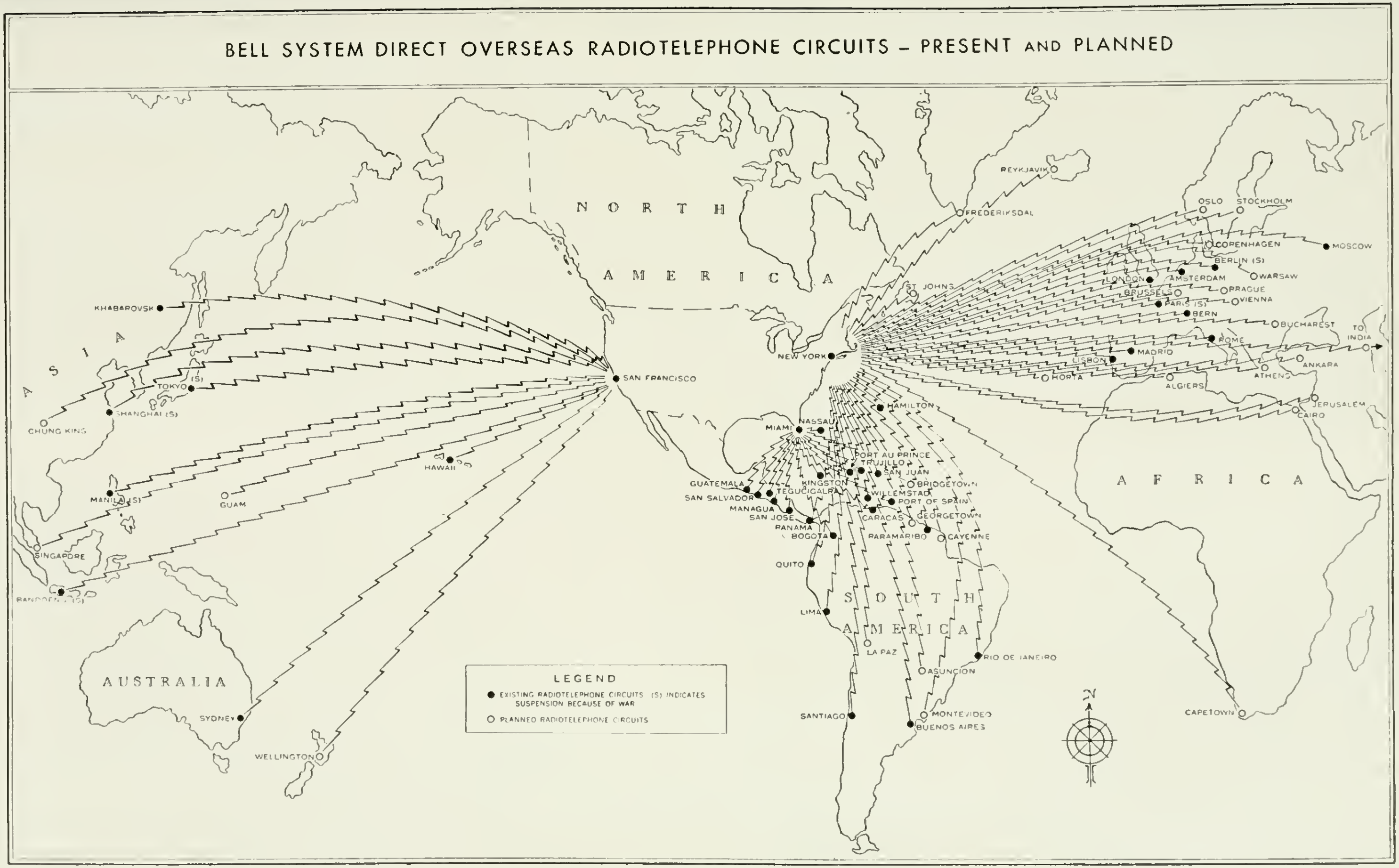

BELL SYSTEM DIRECT OVERSEAS RADIOTELEPHONE CIRCUITS – PRESENT AND PLANNED
NORTH AMERICA
SOUTH AMERICA
AFRICA
ASIA
AUSTRALIA
SAN FRANCISCO
NEW YORK
MIAMI
KHABAROVSK
TOKYO (S)
SHANGHAI (S)
CHUNG KING
MANILA (S)
GUAM
HAWAII
SINGAPORE
BANDOENG (S)
SYDNEY
WELLINGTON
REYKJAVIK
FREDERIKSDAL
ST JOHNS
OSLO
STOCKHOLM
MOSCOW
COPENHAGEN
BERLIN (S)
WARSAW
LONDON
AMSTERDAM
PRAGUE
BRUSSELS
VIENNA
PARIS (S)
BERN
BUCHAREST
TO INDIA
ROME
MADRID
LISBON
ANKARA
HORTA
ALGIERS
ATHENS
JERUSALEM
CAIRO
HAMILTON
NASSAU
PORT AU PRINCE
TRUJILLO
SAN JUAN
KINGSTON
BRIDGETOWN
GUATEMALA
TEGUCIGALPA
WILLEMSTAD
SAN SALVADOR
PORT OF SPAIN
MANAGUA
SAN JOSE
CARACAS
GEORGETOWN
PANAMA
BOGOTA
PARAMARIBO
CAYENNE
QUITO
LIMA
LA PAZ
RIO DE JANEIRO
ASUNCION
SANTIAGO
MONTEVIDEO
BUENOS AIRES
CAPETOWN
N
LEGEND
● EXISTING RADIOTELEPHONE CIRCUITS (S) INDICATES SUSPENSION BECAUSE OF WAR
○ PLANNED RADIOTELEPHONE CIRCUITS

FIGURE 15

well that it has been able to give its customers much more for *their* money.

What the Money Will Accomplish

THERE HAS never been a time in the history of this business when there have been more new developments capable of being translated into better and more valuable service for telephone customers. But let there be no mistake about it: in order to do the job that the System has the skill to do, it is going to need very large amounts of new capital and it urgently needs earnings adequate to enable it to obtain the necessary billions.

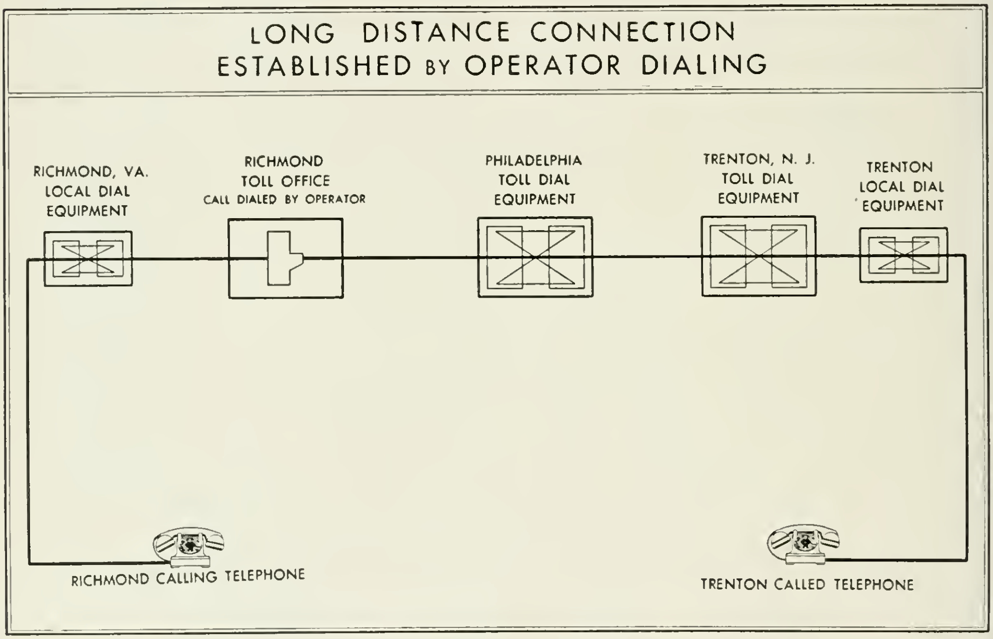

LONG DISTANCE CONNECTION
ESTABLISHED BY OPERATOR DIALING
RICHMOND, VA. LOCAL DIAL EQUIPMENT
RICHMOND TOLL OFFICE
CALL DIALED BY OPERATOR
PHILADELPHIA TOLL DIAL EQUIPMENT
TRENTON, N. J. TOLL DIAL EQUIPMENT
TRENTON LOCAL DIAL EQUIPMENT
RICHMOND CALLING TELEPHONE
TRENTON CALLED TELEPHONE

FIGURE 16

To meet backed up service demands alone the System needs $700 millions of additional plant as fast as it can be put in. Expenditures for new construction will total several billion dollars in the postwar period. In the next five years this may well mean a billion and a half in *new* money from investors; and looking ahead ten years instead of five, the System may require well over two billion—nearly as much new capital as it had to obtain in the whole period from 1920 to 1945.

This new money will be used to the nation's benefit. It will mean giving service to all who now want it, including the more than 2,000,000 people whose applications are being held for lack of equipment. It will provide individual line service to hundreds of thousands who have been on party lines because that was the only service available in wartime, and extension telephones in hundreds of thousands of additional homes. It will mean pushing forward the program to give fast and accurate dial service. It will mean eliminating the "turn the crank" magneto switchboards entirely, providing modern handset telephones for everybody, and introducing new and improved types of key sets and intercommunicating systems.

The System's farm program alone will employ a hundred million dollars and 12 million man-hours of work with the objective of adding another million telephones in Bell rural areas to the million already in service.

It will also mean adding toll plant, including hundreds of thousands of miles of new circuits, to restore toll and long distance service to the standards enjoyed before the war. Further improvement in the speed and accuracy of toll and long distance service will be obtained by the introduction of new equipment and methods which will enable an operator to dial a call through from coast to coast without the assistance of another operator (Fig. 16). Still other developments look to eventual customer dialing of toll calls over long as well as short distances.

The nationwide system of coaxial cables will transmit television programs as well as telephone messages, and radio relay systems will be built to complement and operate harmoniously with the wire lines (Figs. 12, 13). Two-way voice communication will be furnished to connect motor vehicles, boats of all kinds, and trains with any telephone in the land that they wish to reach (Fig. 14). The number of circuits to countries overseas will also be vastly increased and will give improved speed and quality of overseas service (Fig. 15).

To do these things will take men, women, materials, and money. There are many thousands of jobs ahead in the manufacture, construction, and installation of new plant. In the next five years there will be needed, in all probability, 12 million telephones for new customers and for replacements, additional buildings and central office equipment for the rapid extension of dial service, 40 million conductor miles of exchange wire in cable, and toll cable for 15 thousand miles of route. And to help get the work done, some 30,000 new cars and trucks will be needed.

A Dynamic Program

THIS IS a dynamic, forward-looking program. It *can* be accomplished if earnings are sufficiently high to attract from investors the money to build the new improved plant needed. This will make possible plenty of jobs, better service, and more service. There is every reason to suppose that the same American common sense that has made telephone service so progressive in the past will make it equally successful in the future. And always, behind the whole program, stands the policy plainly stated by Walter S. Gifford, President of the A. T. & T. Company, in 1927:

"Earnings must be sufficient to assure the best possible telephone service at all times and to assure the continued financial integrity of the business. Earnings that are less than adequate must result in telephone service that is something less than the best possible. Earnings in excess of these requirements must either be spent for the enlargement and improvement of the service furnished, or the rates charged for the service must be reduced. This is fundamental in the policy of the management."

to the Making of Civilian Telephones and Equipment for Which Millions of Customers Are Waiting

Western Electric Tackles the Peace-time Emergency

Walter M. Reynolds

They're breathing fire and they're moving fast at the Hawthorne Works of the Western Electric Company, in Chicago.

They're in high gear, the place is jumping, and they're speeding around the corner from War Street into Peace Boulevard. Hurry is the watchword.

There were 106 of Hawthorne's great building sections which required complete or partial rearrangement and retooling. Not more than two weeks after the Nips quit, nineteen of the building sections—which are as big as three-quarter-size football fields—had been scrubbed clean of war and were throbbing with civilian telephone manufacture. In another two weeks—one month after the Jap surrender—the nineteen building sections had increased to thirty-five, all at work on peace-time equipment. Besides, reconversion was pounding forward in an additional twenty-one sections of the plant.

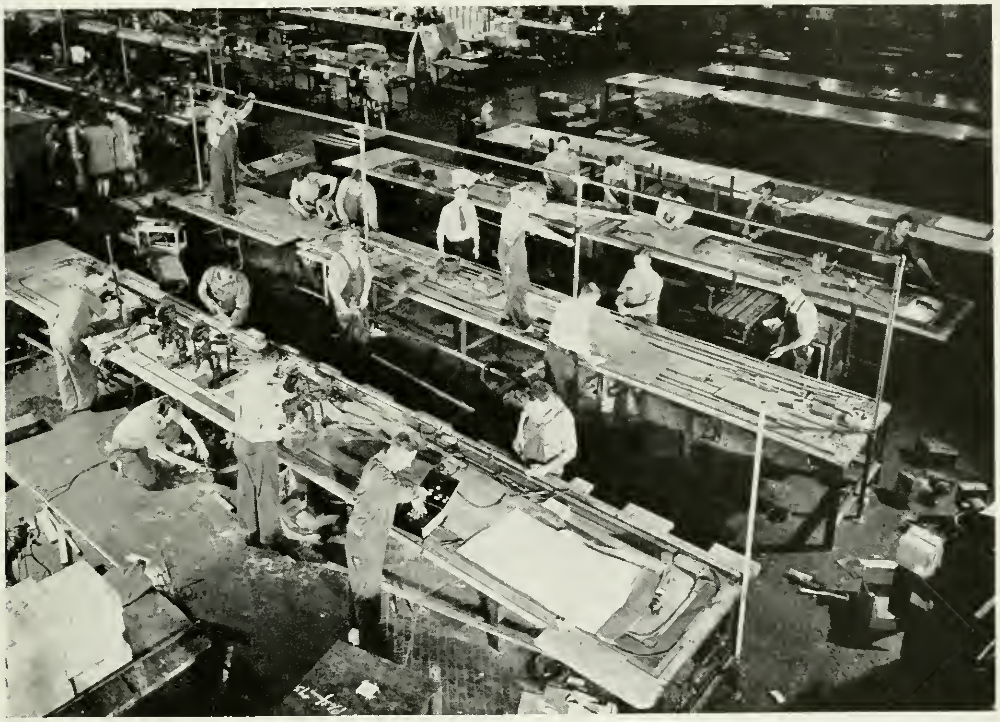
This would sound like a record, and maybe it is, although there is nobody at Hawthorne right now to answer the question. They are all too busy. The records they're interested in at the moment are those having to do with the rate of production of telephones, central office dial equipment, and exchange cable.

Here's the first chapter of *that* record:

Within one month after the fighting was halted, the production rate of central office dial equipment was up more than one and a half times what it had been. And at the end of that same month, combined set telephones were going into the packing cases more than one and three-quarter times as fast as they had at the time the Japs said "Yessir!" to MacArthur and Nimitz.

Before the end of the Pacific war,

some civilian telephones and telephone equipment were being made. The quantity was small in proportion to the great need; but everything was being done that could be done without interfering in the war job.



Millwrights make ready telephone assembly lines to augment those already in operation as Western Electric gears up for new daily production records

That there was an immediate postwar civilian telephone production upswing at Hawthorne demonstrates clearly how Western Electric people, like all in the Bell System, face up squarely to the long line of two million and more of the public who want telephone service and want it quick.

At Western, they are doing everything in their power to supply the things that supply telephone service. And it doesn't take a visitor in their workshops long to decide that they're a resourceful, powerful crew of people!

They are tackling the job of getting their factories back to peace production the same way they and telephone people tackle a rehabilitation job in the wake of a hurricane or flood.

They are doing it emergency-style—

—make temporary connections to the machines . . . run the water and compressed air pipes in quick!

—slap in the power leads, we'll

get them into conduits after a while.

—start the wheels rolling, pronto!

—pick up three days, four days, now, when we need it.

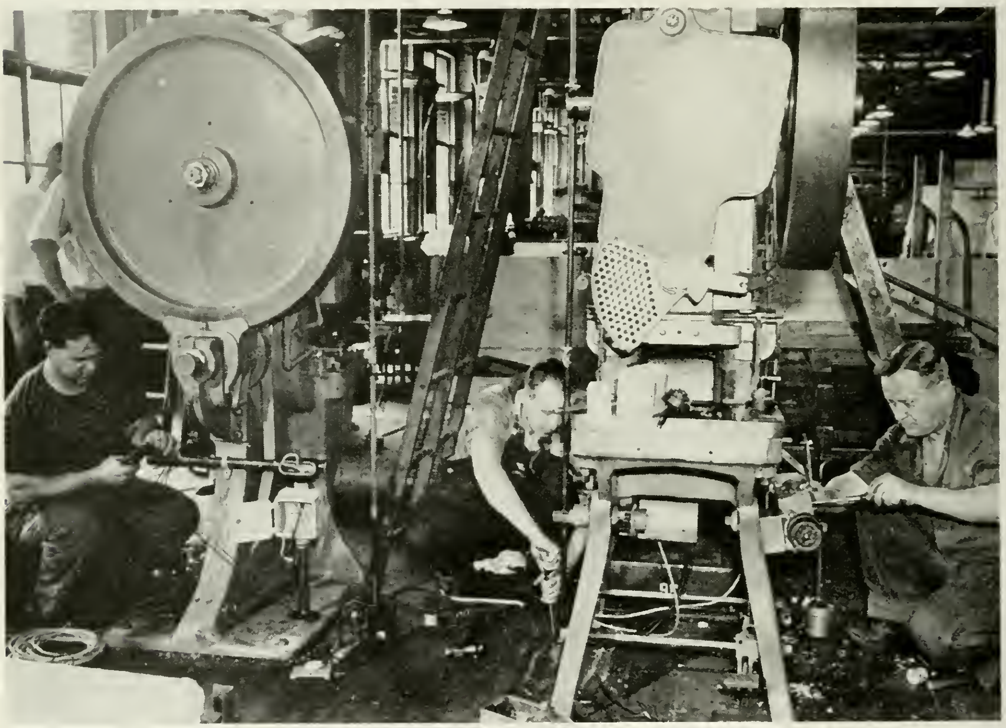
—later will be time enough to clear up the temporary construction!

That's how Western's men and women are getting out the stuff.

Take Charley Carroll. He runs the miscellaneous station apparatus division. He's got black, curly hair, a firm mouth, and a strong chin. Charley sticks that chin out and he puts it in words.

"Look, mister," says Charley, "we're producing high-class telephone sets around here in spite of hell and high water!"

There are thousands like Charley at Hawthorne.



THESE small punch presses are now pounding out piece parts for telephone equipment as the arduous conversion from wartime to peacetime production goes swiftly ahead

Dreams Come True

TO WALK into the Hawthorne shops nowadays is to renew, suddenly, the childhood dreams of Santa Claus's workshop. It is that way for a telephone man, anyhow.

Beautiful shiny black telephone handles glide on their conveyor carriers four abreast in a long line toward the assembly benches.

Glittering cross-bar switch units

swing along overhead trolley tracks to keep a date with cables of gay-colored wires that will be stitched in place with thousands of drops of solder.

Snakes of hot copper looking like neon lights shoot from the rod mill's rolls, are grasped by tongs and fed again to the rumbling machine that squeezes the metal into wire-shaped rods.

A flock of little merry-go-rounds twist pink, yellow, purple, red and green threads into insulating jackets on wires.

In a wire cage a Ferris wheel that would thrill and terrify you if you were Mickey Mouse spins the brilliant wires into cables of garden-hose thickness.

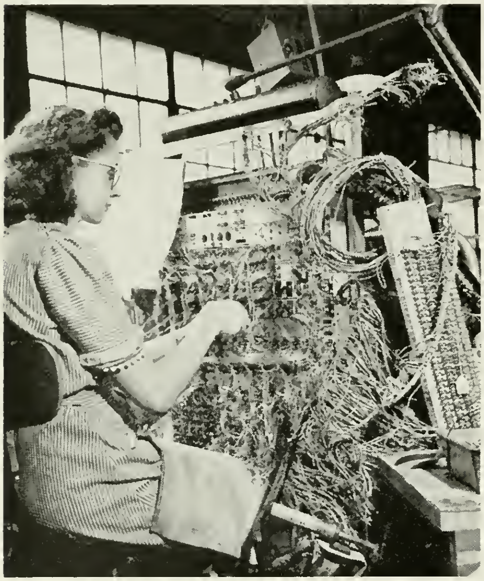
Girls seated like ladies in a circle at a quilting party bend their heads above the conveyor belt on which their nimble fingers assemble delicate transmitter units.

A FEW weeks ago all of these women were working on military communication equipment. Now they are making wire connections on units of central office equipment

A hunchback press stands eight feet tall and goes "Ka-whump" to bite a bar of steel and make another U-shaped magnet for ringer assemblies.

There's the angry buzz of compressed air screwdrivers sinking brass screws into the vitals of combined sets.

A busy little punch press snaps rivets into piece-parts. "Zu-whapp! Zu-whapp! Zu-whapp!" goes the press, and each stroke shouts "Good news! Good news! Good news!" to every telephone man and woman in the land.



WIRING the units of central office switch boards is an intricate operation which calls for training, skill, and care

It *is* good news, tremendously good news to the public and to telephone companies, this action that is taking place at Hawthorne.

That the action is vast and that it is complicated almost beyond comprehension is demonstrated by the sights to be seen and the stories to be heard at the Works.

Western Electric, of course, is a whole lot more than Hawthorne, big as the latter is. There are three major Works—Kearny, New Jersey, which concentrates on switchboards, exchange cable, and carrier systems; Point Breeze, at Baltimore, Maryland, which emphasizes wire, switchboard cords, and toll cable—particularly coaxial cable; and Hawthorne, where the big volume production is in central office dial equipment, telephones, and exchange cable.

Each of these major units makes many other vital elements of telephone plant, of course, and each has many satellite plants. About 70,000 people work for Western Electric, and of these some 21,000 are located at the Hawthorne Works and its supporting plants.

Even Before Pearl Harbor

EVEN BEFORE Pearl Harbor, the crescendo of Western Electric's war work had begun. Military telephones, switchboards, radars, and secret electronic combat devices of many kinds were given the green light. Western Electric, singularly fitted to do this job, was absorbed 85 percent by essential war production. But that is now coming to be an old story.

Here's where the story gets new again!

"All of us," says David Levinger, Hawthorne's Works Manager, "buckled down to a long drawn-out war with the Japs after victory in Europe. We concentrated—you know how we concentrated!—giving the Armed Services everything they asked for, plus.

"Then some time in June of this year, as reports of the Pacific fighting came in, the thought began to grow, 'We could be wrong! We could be wrong . . .' "

In July, Mr. Levinger called in the heads of his departments.

"Maybe this isn't to be a long drawn-out war," he counseled them. "It's time we know exactly what we'll do to meet the needs of the Bell System if the end comes quickly."

A month before V–J Day, he recommended to them that Hawthorne supervision "expect each day that tomorrow will be V–J Day—and plan accordingly."

That is why—without cutting one whit from commitments to the war job—Hawthorne was building up telephone production before mid-August; and why, when V–J Day did come suddenly, plans were ready and machines, men, and materials were poised to tackle the Bell System job.

On V–J Day war production was sharply cut back while civilian telephone production stayed on an all-out six-day basis. Since then, production for civilian use has gone up with quick acceleration as Government needs have fallen away.

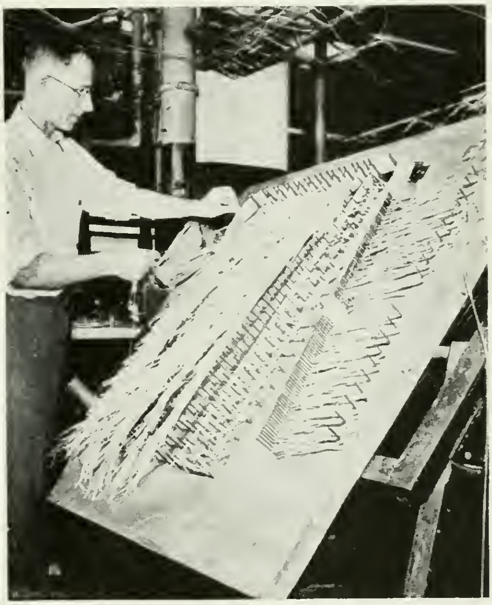
Within two weeks after the Jap war ended, for example, two Hawthorne workers were on telephone production to one who was assigned to war work. A month after the Jap surrender, the ratio was nearly four to one.

Change-over—Plus Greater Production

How do you swing a vast, complex manufacturing organism over from war to peace production?

It is no "put down this book, pick up that one" operation. Remember, war commitments were being met continuously throughout the change-over. And the almost overwhelming pressure of Bell System needs was building up, up . . . so that no thought could be given to the easy way: shut-down, re-organize, relocate machines and shops, and then blow the whistle and start up production.

The war job and the peace job *had* to overlap. There was just that much pressure on Western for its products.



With peace, production of dial equipment is going ahead fast. Here a cable former is "sewing" a line finder cable

Not only was Hawthorne faced with a very rapid changeover from war to peace production; it was confronted with the proposition of establishing production levels, in the cases of most products, at high points far beyond those reached in pre-war years. And it all had to be done—but quick!

They worked out a program which said that by the end of four months after V–J Day they would be turning out telephones at an annual rate of two and one-half million sets. That's the maximum rate ever produced in peace-time.

It means that in the hurried, worried year of 1945—two-thirds a war year, one-third a peace year—Western planned to deliver to the Bell System over a million telephone sets. And in 1946 the delivery program goes up and up and up to nearly three times that many.

Then there's exchange cable. Hawthorne started from behind scratch on this much needed commodity. Before the war, Hawthorne and the Kearny plant divided production of exchange cable for the Bell System—divided it about 50–50. Hawthorne's cable-making plant was wiped out entirely to make room for war work. Now, however, they are again producing cable in large quantities, and in 1946 expect once more to be supplying their half of the Bell

THESE truck loads of switches are to become parts in the Bell System's expanding dial central office installations

System's needs, but in the enlarged quantities required.

Take dial central office equipment. The Bell System needs great quantities because about sixty percent of the applications for service held by the telephone companies are held due to lack of central office equipment and outside plant.

Switches in increasing numbers are moving through the soldering and testing lines of the step-by-step shops

Western has accepted the commitment to produce dial apparatus for nearly a quarter million lines in 1945. In 1946 this will be quadrupled—apparatus for more than a million lines! In 1947 and in each of the years immediately thereafter Hawthorne expects to make dial equipment for a million and a half lines.

That is the "high level" program you hear about in all parts of the Hawthorne Works. You hear it from the office up in the tower of the six-floor Telephone Apparatus building where Mr. Levinger works all the way to the boys in the rod and wire mill.

If you've got manpower shaped into a smooth organization, enough machines and tools, and an adequate supply of materials, you can launch yourself on a program of doubling or tripling your production—provided you also have enough space.

Doubled Production Calls for More Space

AT HAWTHORNE they didn't have enough space, not by 800,000 square feet; but the receding tides of war offered the solution. It was the Studebaker Plant down Cicero Avenue several miles from the Hawthorne Works—a sprawling, one-story, windowless, air-conditioned, almost-new factory where parts were made during the war for Army airplane motors.

There are some 850,000 square feet of space at Studebaker. While the war was still on, rental of this plant was being negotiated to help take care of Hawthorne's expanded war manufacturing needs. Now that peace is here, they're thanking their lucky stars for Studebaker; for the big plant's floor space is where expanded manufacture and assembly of civilian telephone sets will be done in addition to war equipment manufacture that continues.

The occupation of the Studebaker Plant is only a single move—although a large one—in the biggest game of "let's-rearrange-the-living-room" you ever heard of!

Bill Timm tells the story.

Bill is a manufacturing layout engineer, and it is the job of manufacturing layout engineers to plan the physical arrangement of the facilities in the plant. Bill has graying hair. When you've heard his story, you'll understand why he goes home from work and relaxes by doing problems in calculus.

The manufacturing layout engineer's problem begins with the need for more capacity to meet the high-level cross-bar and telephone-set program.

Bill Timm & Company scan the entire Hawthorne Works.

Over beyond 26th Street they see a big six-story building with a one-story extension. On the Works plan this building is down as Building 175, but people around and about call it the 26th Street Building. The one-story portion houses the sheet metal shop and metals manufacture. Before war pre-empted most of this structure with radar assembly, testing, and storage, it was used for switchboard cable manufacture besides the sheet metal operations.

But not any more! This is where cross-bar will now be made. The question is: where shall the sheet metal shop be moved?

All things considered, the 47th Street Building would seem to be the best place to relocate the sheet metal shop. But look what's already in the 47th Street place! There is (a) 755–PBX's, (b) central office power board equipment, (c) K–2 carrier systems, and (d) a shop that has been making coils for Government projects.

To begin with, the manufacture of power board equipment has got to be expanded and will stay right here. But the PBX job is located here only temporarily. It's due to go back to the main plant as soon as war work is sufficiently cleared out there. The K-carrier job transfers to the Kearny plant. This just about fixes up the 47th Street Building to receive the sheet metal shop—except for the Government coil shop. Fortunately for Bill Timm, that shop died when the war ended.

However, there's still an orphan around. Remember? Switchboard cable used to be made back in Building 175 where the augmented crossbar job now is located. And switchboard cable is something we're going to need in very considerable quantity. Where will we start up the manufacture of that?

The answer lies in Building 106. Time was, before the war, when this vast single-story structure housed the manufacture of telephones along with several other things. But war filled up Building 106 with gun directors, computers, and other needed tools of the combat forces. However, the war work there is done now and the switchboard cable work can take its place in the space occupied before the war by telephone set manufacture. The latter, of course, is slated for the Studebaker plant.

"Calculus," says Bill Timm, "is relaxing."

Preparations for Production

And so you can see the kind of ring-around-a-rosy that goes on in reorganizing a war manufacturing plant such as Hawthorne was.

Nothing has been said, however, of the details of the job—the questions which must be answered, like:

—how many machines?

—what type?

—how many people?

—number and type of benches?

—will a given shop operate one shift, two, or three?

More and more miles of wire are spinning off Western Electric's machines every day. This one simultaneously tins 12 bare copper wires which become a protective braiding over rubber insulated conductors

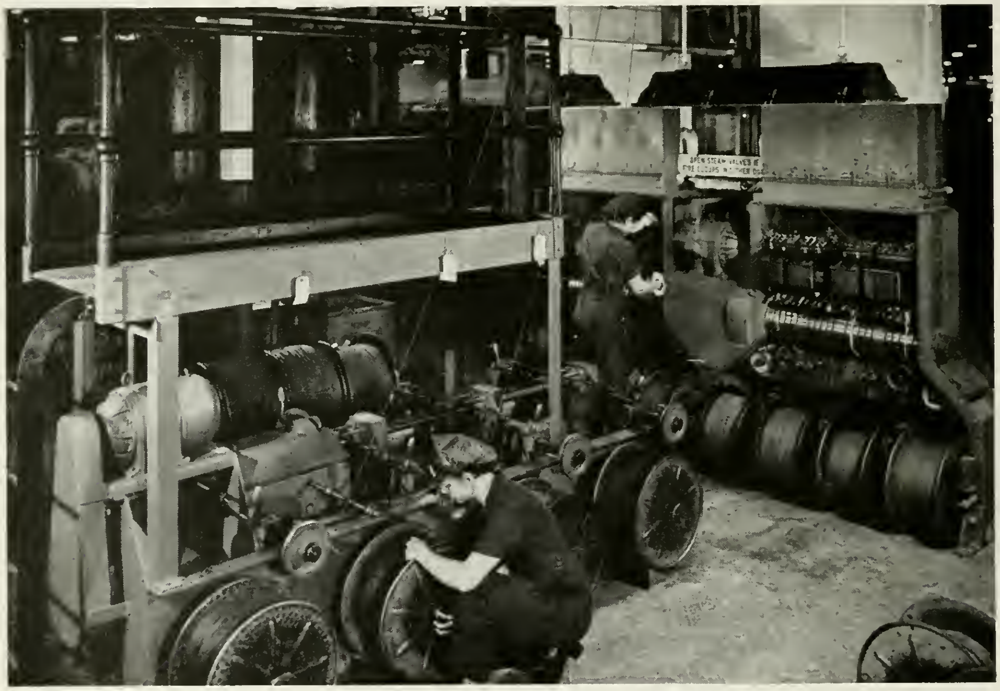
Scenes from all three of Western Electric's principal Works—Kearny, N. J., and Point Breeze, Md., as well as Hawthorne—are among the photographs which illustrate this article

—what about flow of materials and finished parts? Conveyors? Aisle space required?

When dozens of questions like these are answered, it's time to make a model floor plan of each "new" location. Templates representing the actual floor space required by each machine and bench are cut and fitted into a miniature plan. After this comes the "write-up" and the job description, so everybody will know where to put what, how to lay out the power circuits of various voltages, the water, the lighting; build cranes, tools, conveyors. Then it's the millwrights' turn to go in and build and install everything needed.

And to all of this add the problems of raw material supply and of personnel training (at Hawthorne they're doing the unprecedented thing of operating training facilities in three shifts, around the clock), and you gain a sketchy idea of the complexity of the Hawthorne changeover program.

Yet these are merely preparations for production. Manufacture starts from scratch. There's nothing in the hopper in the way of piece parts with which to make, in turn, the sub-assemblies and the final assemblies of telephones, for instance. The piece



EIGHT weather-proofed textile-wound wires are being painted with quick drying lacquer, passed through a drying duct, and taken up on the reels in the foreground parts must be manufactured first; and you can't make piece parts until the raw materials are converted into wire, strips of metal, rods, and shapes of many kinds.

For instance—ringer coils.

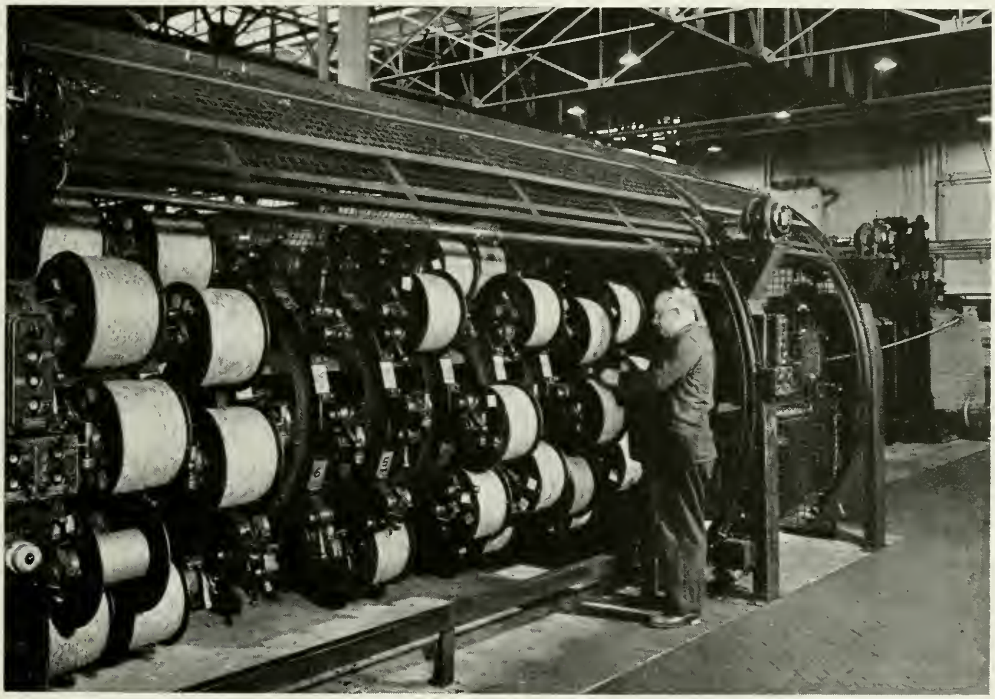
The sound of the telephone bell is, perhaps, the most easily recognized symbol of telephone service.

One of the things that makes the telephone ring is a pair of coils of tightly wound wire, each coil about 1¾ inches long. The wire in the coil is one of the thinnest, most delicate copper strands found anywhere in the telephone plant. It is 39-gauge—and a horse hair is thick and coarse by comparison. So fine is it that women capable of fine needlework invariably are selected to operate the machines which wind the coils, eight at a time, upon a "stick."

Skip, if you wish, the problems of re-locating the winding machines, of combing the plant for women qualified to do the coil winding job, of training them. Look only at the production record:

On the first day that the machines and people were ready to go, exactly ten "sticks" of coils were wound. That's eighty coils, or enough for forty telephones.

That first day was a Monday. On



THIS is one of the big stranding machines which turn out telephone cable. At one loading it holds wire enough to stretch as a single strand from Chicago to Denver the fourth Monday afterwards some 1029 "sticks"—8,232 coils—were wound. Same machines, same girls, same kind of coils. A pretty production picture, you say? Well, it is.

But where did the tiny wire come from that they made into coils?

Hawthorne's wire mill supplies the answer, and *their* production story matches the coil winding story.

Think for a minute of the operation in the wire mill. There they tell you that a pound of copper spun out into 39-gauge wire is 25,040 feet long. It takes 900 pounds of this wire to make 8,232 coils. That's 22½ million feet of wire, some 4,260 miles of it to be produced—daily!

Carrier systems will play an increasingly important part in the nation's growing telephone network. Carrier panels are here being assembled

Yet, on that fourth Monday in the coil winding shop, output was only one-third of what the production program says it is to be when everything is going full tilt.

And a ringer coil is only one of 429 parts which go to make up the combined dial telephone set.

Obviously, the major and minor production feats being performed every day at Hawthorne couldn't be accomplished without a full share of devotion to the ideals of Bell System service.

Ralph Price, manager of the central office division of the plant, talks from the grass roots of his feeling when he stands before his 600 supervisors—as he did on Tuesday evening, September 25—and says: "We can have only one answer to a request from the Bell System, and that's 'Here it is!' "

The same idea was voiced another way by another Hawthorne man—nobody now remembers who—helping to do the rush job of transporting a vital machine from the St. Paul plant to Hawthorne. The machine punched out parts at St. Paul until the whistle blew Saturday night, was ripped up by the roots for the 400-mile truck trip to Hawthorne, was installed Sunday, and was punching 'em out again on Monday morning.

"If only," the man was heard to lament, "if only the engineers could figure some way to give us power, we could run this thing all night on the truck."

Or, there is the story about the Bodine press that broke down.

This press takes a little piece of steel the size of a .22 calibre bullet and crimps it on the end of a three-inch snip of steel wire. The result is known as a clapper ball assembly. It's the gadget that strikes the telephone bell.

According to Joe Podzimek, who is chief of the machine and finishing department, the main bearing of the press burned out one Saturday, just fifteen minutes before the whistle.

TELEPHONE bells, being added here to the assembly of the instrument base, will ring for more and more customers in coming weeks

The maintenance folks came on the run, took one look, and said it was a three-day job to tear down the machine and replace the bearing.

On hand at Hawthorne were enough clapper balls to supply the telephone assembly lines for eight days; but there weren't any to speak of at St. Paul, where the rate of assembly was greater than at Hawthorne. There were enough pieces, if spread between both places, to keep the lines going a day and a half—that would be Monday and Tuesday, up to about noon.

At this point on the final assembly conveyor, telephones become complete instruments—destined to relieve in increasing numbers the war-born shortage which has deprived many families of the service they desired

It might be expected by some that the repair job would be under way Monday morning; and along about Thursday noon supplies of clapper balls would again be in the assembly line hoppers. Only two days lost!

But, of course, what happened was that three men called up their wives that Saturday evening and said, "See you later." They worked all night. On Sunday two men worked all day. They compressed the three-day job into less than two—and the machine started to work as usual bright and early Monday morning.

Maybe Joe Podzimek's boys figured, simply, "Can't hold up production. We'll work tonight."

But a telephone company man would figure it this way: "Two days of telephone production saved means 11,800 more telephones; that's 11,800 people who get telephone service two days earlier."

Joe Podzimek doesn't think the broken press story is worth printing.

"Why that sort of thing goes on all the time around the plant," he protests . . . which only makes the story bigger and brighter.

Engineering Is Humming

One of the tensest spots in the whole of Hawthorne hasn't a machine in it—and won't have.

It's the section which houses the equipment engineering branch, a tremendous, long room lighted brightly by windows on both sides and filled to the walls with busy people.

Hundreds of flat-top desks crowd together in ranks and rows. Some 600 engineers and draftsmen are in this branch now, but double this number will be required to handle the high-level program which faces Hawthorne.

It is big, this section. A longlegged man walking naturally takes fifty-eight seconds to go the length of it. But the astonishing thing is that here are blue prints and records for *all* dial central offices in the Bell System.

Somewhere in this room is at least one man who knows the equipment layout of any Bell dial central office in the land you care to pick out. He knows it in intimate detail—the specifications of its apparatus, arrangement of its circuits, everything. He's got the prints, which are continually kept in agreement with the working plant.

If catastrophe should strike that dial office at noon, by the time a call got through to Hawthorne, work could be under way on its duplication.

Nowadays the engineers here face the Herculean task of going step-for-step with each telephone operating organization as central office additions or rearrangements are engineered and built in this post-war period. Central offices are tailor-made and these are the boys with the tape measures, the pins, and the scissors. If Hawthorne is jumping with activity, then these engineers vibrate!

Bill Hannenberg, division equipment engineer, is a calm fellow; but the frown lines in his forehead deepen when he explains the fix the engineers are in.

"Engineering," he says, "must be six months ahead of the shop. So, at the start of this production race we were six months behind. But we're catching up!"

At best, this story about Hawthorne offers only a high-spot picture of the people there and how they are coming around the corner from war to peace.

They're not doing it with mirrors or tricks, but with hard, slugging work sprinkled with imagination and initiative. It's a procedure that looks awfully good to a visitor.

But already Mr. Levinger, like a locomotive engineer, is looking backward at the critical switch in the tracks over which his speeding train is still pounding.

He says: "At Hawthorne, we faced"—and note the past tense—"the problem of how to produce quickly the greatest volume of telephone equipment the Bell System ever needed in a given time. Simultaneously, we had to get in gear for the future expanded high-level production program.

"The fact that much of this had to be done under the stress of sudden changeover from war to peace meant greater complications confronting us, in that the plant had to be largely rearranged. But now we're in a fair way to meeting our commitments."

At this point the works manager's eyes swing around to the tracks ahead. . . .

"In December we will be mighty close to old-time levels of production. New levels will be reached next year, when new machines will be ready. Then, on a two and three shift basis six days a week, we'll be on the high-level highway."

The Bell System Has a Big Job in Enabling Thousands of Soldiers Returning from Overseas to Talk with Loved Ones at Their Earliest Opportunity

That First Call Home

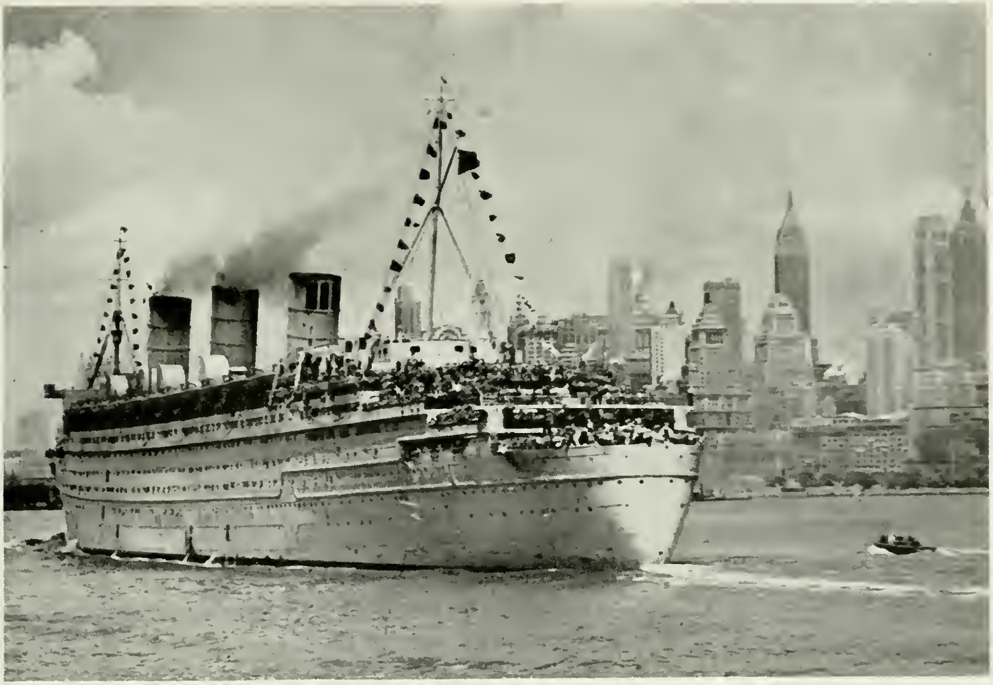
T. Hunt Clark

There is bedlam in the harbor. Whistles are blowing, planes circling overhead, boats bustling through the water, and bands playing. The stately "Queen" proceeds calmly and slowly through the uproar. But her khaki-clad passengers, swarming over decks and lifeboats, are far from calm. They shout, wave, call to the girls of the WAC band playing loudly on the small boat steaming alongside and to all the enthusiastic people on the other welcoming craft swarming around the great vessel.

Here is still another troop ship arriving from Europe with those boys who have not seen America for one, two, three years or more. Up the river the ship is warped to the dock by puffing tugs, the gangplanks are lowered, the victors of the European war start stomping ashore. On the pier are more bands, and also Red Cross aides handing out milk, ice cream, and cookies. Soon the soldiers are off to a Disposition Center (also known as a debarkation camp), the first of the series of camps on the road to furloughs and other Army duties or—more particularly since V–J day—back to civilian life.

Along the east coast are four major Disposition Centers to which the men and women of the Army first go immediately when they arrive from Europe by boat. These are Camp Myles Standish, Mass.; Camp Shanks, N. Y.; Camp Kilmer, N. J.; and Camp Patrick Henry, Va. Most of the service men returning from Europe have come into these camps through the ports of Boston, New York, and Norfolk. Between June 1 and October 1, well over a million service men have passed through these camps. While some men of the A.A.F. have been flown back, landing principally at Bradley Field, Conn., Mitchell Field, N. Y., or Miami, Fla., their number is small as compared with those who have come home through those three ports.

The stay at the Disposition Centers is short: only 12 to 48 hours. From them the soldiers are transported to one of 26 Personnel Cen-



STEAMING PAST the towering sky-line of lower Manhattan, the "Queen" heads for her berth with nearly 15,000 returning troops aboard—most of them on deck for the first sight of their welcoming and grateful country in many long and weary months

ters which are located throughout the country. Each man is sent to the Personnel Center which is nearest his home and there, after going through various steps of "processing," lasting one to three days, they either receive a furlough before further assignment or are discharged.

Freedom of the Camp

ON ARRIVAL at the Disposition Center, the various groups march to their barracks. Next they are given a fine meal, of which beefsteak is frequently the "piéce de resistance." Then comes "briefing" by officers on the regulations of the camp and the steps in their processing, new uniforms, and, finally—the freedom of the camp.

This is it—the long-awaited first opportunity to telephone home. The rush to the nearest telephones is a sight to behold—and, of course, a challenge to the resourcefulness and ingenuity of the telephone company to see that their calls go through as quickly as possible.

By far the most popular spots in the camp are the attended public telephone centers—perhaps six or seven in number—which are conveniently located in the various areas and are now ready to start completing those all-important "first calls home." Even if there were no sign posts and the men had not been furnished with maps of the camp showing the location of the telephone centers, all a soldier need do would be to follow the crowd and he would arrive at a telephone center.

These centers are in regular Army buildings which have been made available to the telephone company. Inside, the boys find comfortable chairs and benches, telephone directories, telephone booths, a commercial manager and, behind a counter, a row of pleasant, helpful girls ready to record their calls and pass them to the switchboard operators for completion. Whether a call be to a point near by or far distant, whether it be simple to complete or one calling for ingenuity and perhaps for the help of others to bring the called person to a telephone, the attendants and operators at the telephone center take great satisfaction in putting it through, since they know how important it is to the soldier making it.

The soldier gives the details of his call to one of the counter attendants. Then, after an interval which may be brief or sometimes long, over a loudspeaker comes the announcement, "Private Carter, calling Akron, take booth six, please." Eagerly, or perhaps with anxious heart, the soldier hurries to booth six, closes the door upon his first moments of contact with home—and out over the wires

Between "shipments" at a Disposition Center: flower boxes for color, benches for comfortable waiting, signs and flood lights for easy identification go magic words which are, most typically, "Hello, mom! I'm back!"

It takes very little imagination to picture what these telephone calls mean to the soldiers. Just watch the eager expressions on their faces as they dash for a booth. Look at their half tearful smiles as they talk with the folks at home or to their sweethearts. And, finally, see their air of satisfaction after they have finished talking. The commanding officer of a Disposition Center recently said on a radio broadcast: "A vital part of our activity here is to maintain the high morale of returning veterans while they await transportation to the next stop. We have found that one of the most effective ways to accomplish this is to have adequate telephone facilities available. That first call home means a great deal to soldiers who have been serving overseas for many months and its importance as a morale factor cannot be overestimated."

To serve the men arriving at one of these Disposition Centers takes a good deal of equipment, a good many people. One camp's six attended centers have 37 switchboard positions, 144 booths, 148 trunks. There are 10 Commercial camp managers on public telephone activities; a Traffic manager; nine chief operators; 280 Traffic operators, clerks, cashiers,

Inside a telephone center, pleasant attendants record the calls and hand the tickets back to the operating positions and supervisors—all adding up to a total of about 300. This number does not include the many Plant Department people who do the installation and maintenance work at the Disposition Center. Add to this the people and facilities at the other Disposition Centers and Personnel Centers—and serving the returning soldiers becomes a very sizeable undertaking.

Recently 28,800 men were received at one of these camps. They were "processed out" by the Army and were on their way to Personnel Centers within 24 hours. But during those 24 hours nearly every man wanted to make a telephone call, and some had lists of calls to make for their buddies who were still overseas. The load that such concentrated calling throws upon the telephone facilities at the camp, nearby toll offices, and the network of long distance lines is tremendous. During this period as many toll calls were handled at the camp as are normally handled in the same period by the toll office of a city the size of Columbus, O., or New Orleans. Under conditions such as these there are, of course, unavoidable delays on some calls; but the telephone companies set out to see that, as far as it is physically possible, every man who wants to make a call will have the oppor-

PHOTOGRAPHED during a period of light use, this picture illustrates the comfortable furnishings and friendly atmosphere in the telephone centers tunity to place it and get it through before he leaves the camp.

The telephone companies distribute booklets to the men coming into these camps which tell them what is provided at the camp in the way of public telephone facilities. Generally a map of the camp is included, showing the locations of the telephone centers and also of other camp service buildings.

In some of the large Disposition Centers, the telephone centers may be quite widely separated, in order to locate them conveniently throughout the entire camp area. It sometimes happens, therefore, that certain of the telephone centers will become crowded while other centers are not. Where this happens, cars or buses are provided to transport men who have not yet filed their calls to the less crowded centers. There are also arrangements whereby the central office trunks coming into the camp can be redistributed among the switchboards at the centers to provide additional outlets at the busier centers.

The telephone centers are kept open as long as there are men back from overseas who want to place calls. This requires 24-hour service on some days at some or all of the centers, and a large complement of switchboard operators, attendants, camp managers, and supervisory per-

TELEPHONE directories for many cities help to speed calls by number—and give the men a feeling of being really close to home sonnel to work in shifts around the clock.

What It Takes

Let us see what goes on behind the scenes at a Disposition Center, from the telephone standpoint, when a large shipment of men is about to come into port. The returning soldiers of the last shipment left yesterday for various Personnel Centers, and at present the camp is relatively deserted. The camp manager, a telephone company Commercial employee assigned to spend his full time at the camp, has been maintaining close liaison with the camp Signal Officer. The Signal Officer has been and is helpful in many ways, and he is intensely interested in doing everything he can to assist the company in providing the best possible public telephone service for the home-coming soldiers. He is probably as proud as the telephone people themselves of the spacious, attractively furnished telephone centers, which he was instrumental in obtaining, and he is appreciative too of the interest shown by all the telephone men and women who work at the camp.

The Signal Officer now informs the camp manager that the "Queen" is scheduled to arrive at the port some time in the morning of the day after tomorrow, and that five other smaller transports are also due about the same time. He says that 15,000 out of 20,000 men arriving in port are scheduled to come to this camp—information he has received from the Army Transportation Corps.

With this information the camp

WELCOME BACK
Welcome Home!
I'LL BE SEEING YOU IN BUILDING 452
NEW ENGLAND TELEPHONE COMPANY
A Call to be Remembered
WELCOME to the States
Boston Port of Embarkation
Camp Myles Standish

Booklets inform the men about the telephone service provided for them, and suggest how they may use it most satisfactorily manager and his Traffic and Plant Department colleagues begin to set up tentative schedules for assistance at the telephone centers. All of the centers will be open until probably midnight on the day the boys arrive in camp and some will be open all night. Arrangements are made to insure that there are enough Commercial people on hand. The Traffic Department begins setting up tours of duty for additional operators and attendants at the camp and at nearby toll offices. The Plant Department makes a re-check to be sure the equipment is in good working order.

During the afternoon of the day before the ships are due, the Transportation Corps is able to set a fairly definite time at which they will dock; and later it may furnish a detailed schedule of the arrival of trains and buses at the camp, with the number of men in each convoy. The Army is also able to state the numbers of men who are scheduled to proceed to the various Personnel Centers. This gives a good indication of what will be the geographical pattern of the calling, since the men go to the Centers nearest their homes. If it appears from this information that there will be a concentration of calling to the Southwestern states, for example, circuit rearrangements are made wherever possible to help handle the load, to augment the telephone paths leading to that section of the country; and plans are made to insure that the necessary operating force is on duty at the toll switching points along the way.

With these data at hand, final arrangements for scheduling telephone

Welcome to your last s
army! You'll be going
Before you go, there
things you will have t
We won't keep you long.
you're anxious to get wh
going, and we want to
get there quickly. Look
what happens to you her

YOU FILED YOUR CALL AT .... A.M. P.M.

To help you estimate how soon your turn will come, we will announce frequently the filing time of calls being handled.

Unusually heavy calling makes delays unavoidable. We're sorry, and you may be sure we shall do all we can to complete your call as quickly as possible, in the order in which it was received

A MAP of the camp is usually included which shows, among other points, the locations of telephone centers personnel are made. On the morning of the expected troop arrival, the telephone forces begin converging on the camp by train, bus, and automobile. The skilled work of operating the switchboards in the telephone centers is necessarily done by trained Traffic employees. In addition to the regularly assigned telephone company people, there are others who have answered the telephone company's appeal for part-time help: women from telephone central offices, from women's clubs and civic organizations, and others reached through newspaper advertising, who have felt a tug at their heartstrings when they learned that more and more help was needed at the near-by camp to enable the telephone company to give service to the boys coming home. Telephone company men who have other regular duties are there also to help in every way possible.

So, when the first train loads of joyous soldiers arrive, some two or three hundred telephone people are either at the camp, ready to give service, or are prepared to take over in the later shifts.

And then the rush begins!

The Sergeant Is Bashful

HERE IS a dialogue typical of many which might be heard at any telephone center in a Disposotion Center:

A lanky sergeant comes up to the counter where a girl is recording the details of the calls the men want to make. She smiles and says:

"Where do you wish to call, Sergeant?"

"Out near Tulsa, Oklahoma, ma'am, but s'far as I know there's no telephone near where my gir— where the party lives."

"Is there anyone who lives near enough to bring her to the telephone —perhaps a grocery store or a neighbor?"

"Well, there's a general store 'bout a mile from the farm—they always were pretty nice 'bout calling folks to the phone—only I can't remember the name of it to save my life. You see, I was only there just once."

"What town would it be in?"

"A little place called Durham."

"And what's the name of the party you wish to call?"

"Miss Mary Smith, ma'am."

"We'll try to locate her for you, Sergeant. It may take a little time but we'll do the best we possibly can."

"Thanks a lot. You know, I'm not even sure if she still lives in the same place."

"We'll give you a report anyway. And don't be discouraged—we've completed calls here that looked a lot less likely than yours."

"You will be takin' a great load off my mind if you can locate my— my—"

"That wouldn't be 'sweetheart' you're trying to say, would it, Sergeant?"

"That is just the trouble, ma'am. You see, I've been away so long and the last time I've heard from her was over a month ago. So I don't rightly know just how things stand."

The operator tries to get information from the general store in Durham but the telephone doesn't answer. The operator in Durham reaches the proprietor at his home and he says that Miss Smith is visiting Mrs. William Jones in the town.

"We're trying to get Miss Smith at the residence of Mrs. Jones. They are ringing now."

"Gosh, I remember Mrs. Jones. She *must* be there."

"We have Miss Smith now. Booth No. 3, Sergeant."

"Geronimo! Look out below, here I come!"

and the men are encouraged to use them before filing their calls. A great percentage of the calls have to be placed by name and address, none the less, since many of the men, away for a long time, have forgotten the number they wish to call—sometimes even their own home telephone number. Also, many of the families and friends of the men have moved since they went overseas and are perhaps "doubling up," as is so common in wartime. However, the camp manager spends a good part of his time around the directory racks helping the men to find the listings they want.

DURING busy evening hours, outside benches are popular with men waiting for their calls. Loudspeakers summon them inside when their calls are ready

The Personal Touch

TELEPHONE CALLS placed by number can be completed faster than when only the name and address are given. So the camps have comprehensive libraries of directories covering the larger cities of the country,

The camp managers and other

company representatives circulating among the men are very busy people at these times. They move through the crowd, answering question and being of assistance to the men in every possible way. So many of the men don't realize that, even though their family does not have a telephone or they don't know the number, in most cases the call can be completed somewhat in the manner of the sergeant's call just described.

The prime job of the managers and their assistants is to provide a personal relationship between the soldiers and the telephone company, to explain the special measures taken by the company to provide the best service possible, and, when necessary, to give the reasons for delays on some calls.

Many human interest stories could be told of the day-to-day (or night-to-night) life of the telephone people at these camps. A soldier, to cite just one instance, had been for some time slumped dejectedly in a chair in the center—a signal that here, perhaps, was a chance to be of some special service. The camp manager engaged him in friendly conversation and the soldier finally told him that he had to call the parents of a buddy who had been killed in action, and he dreaded it beyond words. The manager suggested that they consult the Chaplain, and the upshot was that the Chaplain made the call for the

A COMFORTABLE BUS, clearly marked, takes men to less crowded centers where their turns may come and their calls be completed more quickly

HERE are some of the 245 operators and attendants who render service at the telephone centers in one camp

---

boy. As the two left the center, the boy said, shaking the manager's hand, "Thanks a million! And say, Don Ameche certainly invented a wonderful toy!"

At the Personnel Centers, to which the soldiers go from the Disposition Centers, the conditions are somewhat less strenuous. The men are there several days, they have more free time in which to make their calls, and most have already made that exciting first call home. Yet the telephone centers with which all of these camps are provided also handle their quotas of joyful calls:

"Hello, mom! I'm just twenty miles from home—I'm on my way!"

"Hi, sweetheart! I'm shipping out tomorrow morning and the train is due in at 4 P.M. You'll be at the station?—Swell!"

It has taken foresight, ingenuity, and near-miracles to meet this challenge of producing more booths, switchboards, circuits, operators, attendants—to mention a few items—in the face of war-time shortages. But it had to be done and, somehow, it was. The Long Lines Department made two circuits grow where but one had grown before. The Associated Companies scoured their territories for booths, telephones, and switchboards with which to provide so important a service. Intensive recruiting campaigns brought additional people from inside and outside the Bell System to lend their efforts to getting the calls through for returning soldiers.

Shortly after V–E day, three Bell System regional conferences were held at which the expected problems and the ways and means of meeting them were discussed. They were attended by Headquarters and Associated Company people from the Commercial, Traffic and Information Departments, and by representatives of Long Lines. It was recognized that extraordinary measures would have to be taken if the System was to get through the calls that all these boys would want to make in the short time they would be in camp.

"Hello Mom—I'm back!"

While there already were attended telephone centers at most of these camps, between May 1 and September 1 the number of centers was increased from 49 to 71 and attended telephones from 600 to 946 in the four large Disposition Centers on the east coast and in the 23 Personnel Centers which are in Bell System territory.

With the cessation of hostilities in the Pacific Theater, considerably larger numbers of Army men will be returned to this country in the months immediately ahead, to both the east and west coasts, than was anticipated last summer. In addition, the Navy has started its demobilization, and has designated stations all over the country as primary receiving points and as separation stations. The Associated Companies are setting up similar attended public telephone centers at these locations.

Of the many tremendous tasks which the Bell System has accomplished, in the face of scarcities of materials and facilities and help, since war first loomed black on the horizon, none has had greater thought, attention, and whole-hearted interest than the provision of public telephone service for the men and women of the armed forces.

Until the bright days of victory, so recently come, the great need was at the hundreds of camps and training centers throughout the country where the outlook was toward Europe and the Pacific. Now, and suddenly, millions of men are looking and coming toward home. It brings new problems to the nation's telephone system—some of which have been sketched here. Some of them are most difficult to meet, mainly because there are not enough long distance circuits in existence to handle as promptly as the telephone companies would like the calls of thousands of men all anxious to hear some loved voice at the first possible moment.

Perhaps this account has made it evident also that the System is doing and will keep on doing its utmost, in spite of real and continuing obstacles, to enable these returning veterans to make what are to them just about the most important calls in the world. It is a big job. And it won't be finished until, many months hence, stepping into a booth at a camp telephone center, the last man back makes his first call home.

Who's Who & What's What

(*Continued from page 135*)

In 1916 he came East to be engineer in the Traffic Department of Long Lines, and in 1921 he joined the commercial division of the Department of Operation and Engineering of the A. T. & T. Co. From 1925 to 1928 he was general commercial manager of the Southern California Telephone Company at Los Angeles, returning to A. T. & T. in the latter year as sales and development engineer. Since 1930 he has been special services engineer in the O. & E. commercial division, and is concerned with new equipment and special services, program transmission, Government contracts, and similar matters.

(Photographs on pages 189 and 190 by courtesy of Transcontinental and Western Air Inc.; other illustrations by courtesy of the Civil Aeronautics Administration.)

Taken all together, the various kinds of facilities which the Bell System has for transmitting various kinds of messages add up to an impressive array; whatever the intelligence to be sent by electricity, the means exist for handling it. H. I. Romnes describes the particular capabilities of different types of circuits, and their respective places in a comprehensive system of communication. For seven years, beginning in 1928, Mr. Romnes was a member of the technical staff of Bell Telephone Laboratories, where he was engaged on a variety of developments. In 1935 he joined the transmission section of the Department of Operation and Engineering of the A. T. & T. Company. His experience since then with the many phases of voice and carrier toll systems led to his appointment early this year as head of the toll group in the transmission section.

The Civil Aeronautics Administration Controls Flights Over 35,000 Miles of Federal Airways Through Facilities Designed and Furnished by the Bell System

Guardians of the Skyways

H. C. Lauderback

While the huge airliner, fully laden with passengers, air mail, and air express, cruises along at close to 200 miles an hour on the last hundred miles of its transcontinental journey, its captain hears in his earphones the reassuring "dah-dit" of the radio beam, telling him that he is safely on his course. As he approaches Metuchen, New Jersey, a conspicuous yellow light flashes on his instrument panel and he hears another radio signal, informing him that he is over the radio marker at Metuchen which gives him the exact location on his course regardless of weather conditions or time of day.

Now he throws the key of his radio transmitter and speaks to the radio operator of his company at the airport: "Fifty-eight—Metuchen—O Eight—Three Thousand—Coney One Three—La Guardia One Eight." From the radio operator he receives this response: "Roger—Fifty-eight—Metuchen—O Eight—Three Thousand—Coney One Three—La Guardia One Eight—Kollsman Thirty Twenty-three." The captain replies: "Roger—Kollsman Thirty Twenty-three," and switches off his radio.

In this conversation over the radio telephone between the airplane and the flight superintendent's office on the ground the captain of the plane has told his radio operator at the airport that his ship, Flight Number 58, was over Metuchen at 8 minutes after the hour (in this case 1 P. M.); that he was flying at an altitude of 3,000 feet; that he expected to arrive over Coney Island, the next check point, at 13 minutes after 1 P.M. and over La Guardia, his terminal airport, at 18 minutes after 1 P.M. The airport radio operator's "Roger" told the captain that he understood the message, and he then repeated it for checking purposes and added the information that the barometer reading at the airport was 30:23. This the captain acknowledged, and repeated for checking, and he then adjusted his altimeter to the Kollsman reading to be sure that he knew his exact altitude. The radio operator at the airport made a written record of this information and immediately reported it to the traffic control office of the Civil Aeronautics Administration, which supervises the flights of all airplanes flying over the Federal airways.

Over Coney Island, the next check point on the route, a similar procedure is followed except that after the interchange of information between the captain and the radio operator the captain advises the radio operator that he is "changing over"; that is, switching to the radio frequency of the control tower at La Guardia Field, which assumes control of the plane for landing, gives the captain the necessary information as to wind direction and velocity, barometric pressure, other nearby planes in the air, and directs him to the proper runway at La Guardia Airport. After he lands and taxis to the position assigned to him, he switches back to his

A COMMERCIAL PLANE's officers have ready contact by radio telephone with the C.A.A. control tower while at and near the airport, and with the office of their company's flight superintendent at other times during flight own radio operator and reports his time of landing.

This young woman, a radio telephone operator for a commercial air line, is conversing with a pilot in the air and recording his report

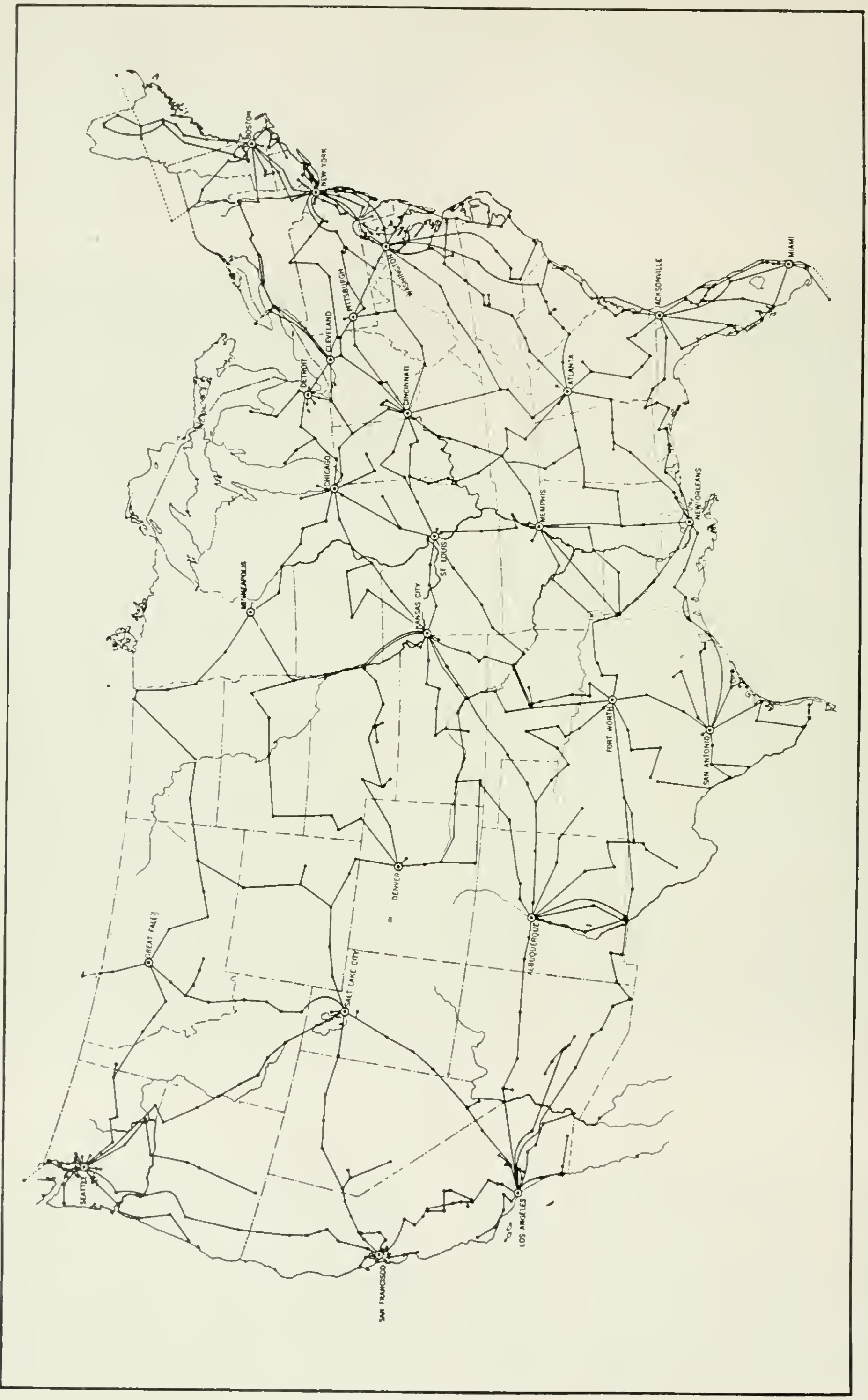
Thousands of messages of this type fill the air today and they all have to do with the operation safely and "on schedule" of more than 500 commercial transport planes and thousands of military aircraft operating on scheduled flights over more than 35,000 miles of Federal airways. Back of these messages is the elaborate communication system and the efficient personnel of the Civil Aeronautics Administration. One of the principal measures of the adequacy and efficiency of the C.A.A. communications facilities and its general system of control is the fact that a recent Annual Report of the Civil Aeronautics Administration shows that the passenger fatalities per 100,000,000 passenger miles flown by commercial airlines has decreased from 11.2 in 1936 to 2.1 in 1944. In the same period, airplane flights along the Federal airways have multiplied many times over.

This extensive and efficient traffic

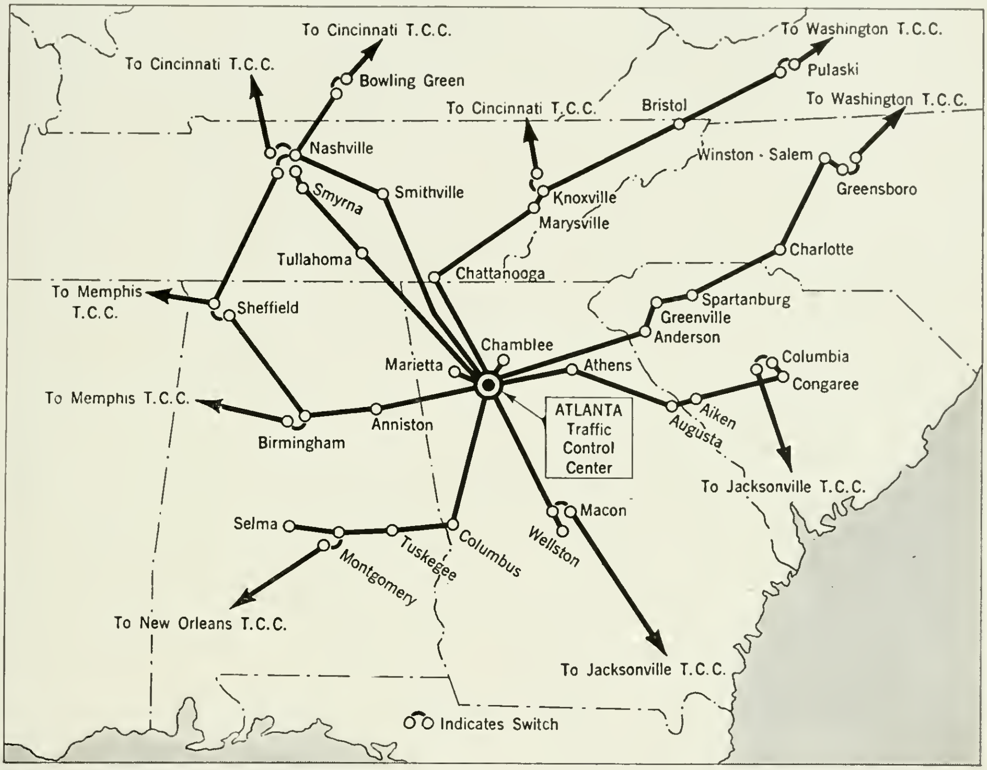
control system of the Civil Aeronautics Administration has grown from a modest beginning. Scheduled air transportation in the United States may be said to have started in 1918, when the Post Office Department opened the first air-mail route between Washington and New York. Army planes and Army pilots were used in this initial undertaking, and flying was done only in the daytime and in good weather. In 1922 the Post Office Department undertook experiments in night flying. The airway between Chicago and Cheyenne was equipped with revolving light beacons, and over this route the world's first regular night air-mail service was inaugurated on July 1, 1924.

Air traffic at and near the airport is controlled by radio telephone from this C.A.A. control tower

In February, 1925, the Postmaster General was empowered to make contracts with commercial airplane companies for carrying the mail. This quickly attracted private capital, and a number of air transport companies were organized and started operations within the next two



THE C.A.A. interphone network covers the country. The 25 airways traffic control centers are indicated on this map years. In September, 1927, the Post Office Department turned the air-mail business over to the commercial airlines.

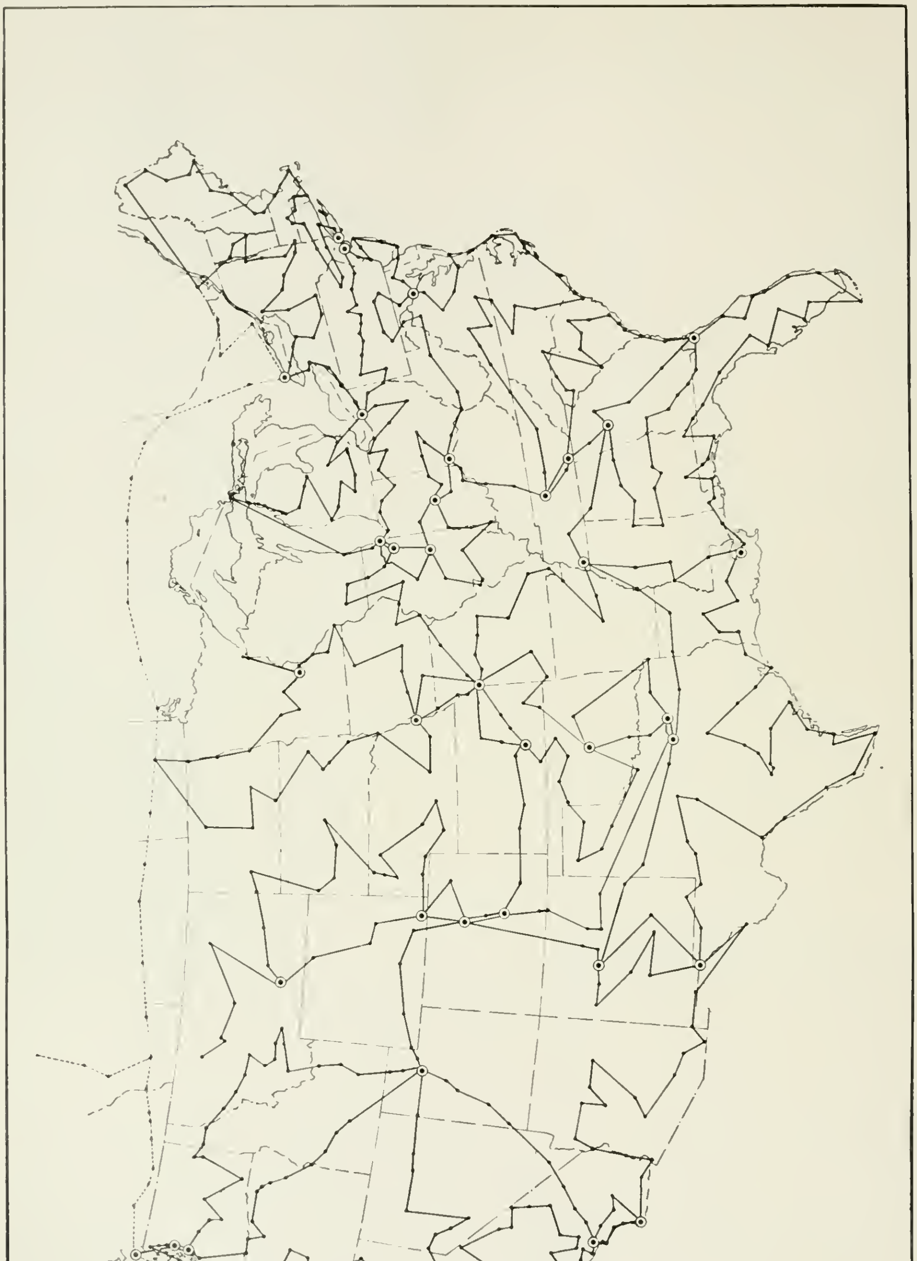


THIS DIAGRAM of the Atlanta airways traffic control area illustrates the layout of the C.A.A. interphone network

Beginnings of the C.A.A.

IN MAY, 1926, before the commercial airlines took over the air-mail operations, Congress passed the Air Commerce Act, which for the first time put all civil aviation under Federal control. The Airways Division of the Bureau of Lighthouses of the Department of Commerce was created at that time, and was charged with the responsibility of providing navigational aids and of regulating and controlling civil flying. This agency took immediate steps to provide light and radio beacons along all airways and also to establish radio stations for communicating with airplanes in flight. The present authority for air traffic control is vested in the Civil Aeronautics Administration, now an independent division of the Department of Commerce.

The functions of the C.A.A. consist principally of certifying planes



The C.A.A.'s extensive teletypewriter networks handle weather information and supplementary traffic control data. One of these networks is shown on this map and commercial and civilian pilots; establishing, equipping, and maintaining Federal airways; gathering detailed information regarding the weather and issuing frequent weather forecasts; providing information to airplanes about landing conditions and other air traffic; providing navigational aids; and exercising control of take-offs and landings at airports and of flights by instruments over the Federal airways.

There are two major divisions in the control of air traffic: Air*way* Traffic Control, which exercises supervision over the airways between cities; and Air*port* Traffic Control, which exercises control at and in the vicinity of the airport. The C.A.A. has always had the first division under its supervision. Before the war, local airport authorities controlled the airport traffic, but with the outbreak of hostilities the military authorities asked the C.A.A. to take over and control the traffic at more than 100 airports.

FROM THE BEGINNING, the C.A.A. system of air traffic control has been built around adequate communications. The Bell System was called upon about the middle of 1928 to provide private line teletypewriter service between Hadley Field in New Jersey and Cleveland Airport in Ohio, including many intermediate points. Within a year this service was extended to Chicago, and the service was used both for collecting and disseminating weather information and for reporting the whereabouts of planes and their departures and arrivals.

The C.A.A. concluded, however, that for the dispatching, operation, and control of airplanes in flight, private line telephone service was much superior to private line teletypewriter service, since it provided direct voice communication. Consequently, plans were formulated to establish traffic control centers at a number of important airports, from which private telephone lines would radiate to various points at the airport and to other airports within the area over which a traffic control center would have jurisdiction. These inter-exchange private-line telephone circuits have been designated as "interphone circuits" by the C.A.A., and by that term they are now commonly known.

All inter-exchange interphone circuits are designedly "party lines," to which telephones at several locations are connected. To give all stations on a line continuous access to the information passing over it, a constantly actuated loud speaker is connected at each location, but is so arranged that lifting the associated hand-set telephone automatically cuts it off. At the traffic control centers and at some outlying points the lines are terminated in key equipment, specially developed for the job by the Bell Telephone Laboratories, which permits quick selection of any one of several lines for either calling or answering. Signaling from the outlying points to the traffic control center is provided by means of push buttons which operate buzzers and signal lights before the traffic attendants at the control center.

A Wartime Emergency

THREE traffic control centers had been established by July, 1936. By June, 1941, a few hundred miles of interphone circuits had been installed and 14 traffic control centers were in operation, at Atlanta, Chicago, Cincinnati, Cleveland, Detroit, Fort Worth, Los Angeles, New York, Pittsburgh, St. Louis, Salt Lake City, San Francisco, Seattle, and Washington.

Special key equipment and control boards in a C.A.A. airways traffic control office

As the Germans ravaged Europe and the Battle of Britain reached its height, the situation in this country grew increasingly tense, and during the Summer of 1941 the C.A.A. summoned representatives of the Bell System to confer upon a program calling for a major expansion of its activities—and an even greater extension of its communication system. This program included the establishment of nine more traffic control centers, at Albuquerque, Boston, Denver, Great Falls, Jacksonville, Kansas City, Memphis, Minneapolis, and San Antonio; and called for not only the installing in these nine traffic control centers of the types of equipment already described but for the provision of *30,000 more miles* of interphone circuits. The time schedule required completion by June 1, 1942—somewhat less than a year.

Then, while the design, manufacture, and installation were proceeding according to that time-table, the Japanese attacked Pearl Harbor—and that blow altered the situation completely. For now the nation was at war, and the needs of aviation and the importance of Federal airways and communications for airway control were immeasurably enhanced.

Again System representatives were called to Washington. The previous schedule was thrown overboard and in its place the C.A.A. set: *the shortest possible time.* It was a challenge —and one superposed on all the other requirements for more and more circuits and equipment of a country suddenly plunged in war. Yet by the following Spring the seemingly impossible had been accomplished. The Western Electric Company had made the additional special equipment required, including many hundreds of loudspeakers for not only the new but also the existing traffic control centers, and the System's Associated Companies had placed it in operation. They and the Long Lines Department had built thousands of miles of new physical circuits and installed hundreds of equipments to create additional thousands of miles of carrier circuits. In territories which concerned them, independent telephone companies played their constructive part. The need for private-line teletypewriter service was no less urgent, and the provision of thousands of miles of these facilities was carried forward

The teletypewriter section of a C.A.A. airways traffic control office at the same time. It was a war job, done under great pressure—and to the expressed gratification of the C.A.A.

It could not have been done in that short time, nor done without greater difficulties, but for the continuously helpful and constructive attitude of the C.A.A. representatives concerned with communications requirements. From that organization's inception they have worked in friendly co-operation with telephone people to solve their problems and to provide the facilities which their service to America's aviation demands.

Bell System Facilities

TWO MORE traffic control centers—Miami and New Orleans—were established early in 1945, making 25 in all. The Bell System is now furnishing to the C.A.A. about 50,000 miles of inter-exchange private-line telephone (interphone) circuits. Of this mileage, some 26,000 miles is provided by the Associated Companies and 24,000 by the Long Lines Department.

The C.A.A. is also using 94,000 miles of private line teletypewriter circuits. The largest part of these private line teletypewriter circuits is furnished by the Long Lines Department; some mileage is furnished by the Associated Companies; and the Western Union Telegraph Company also provides one network.

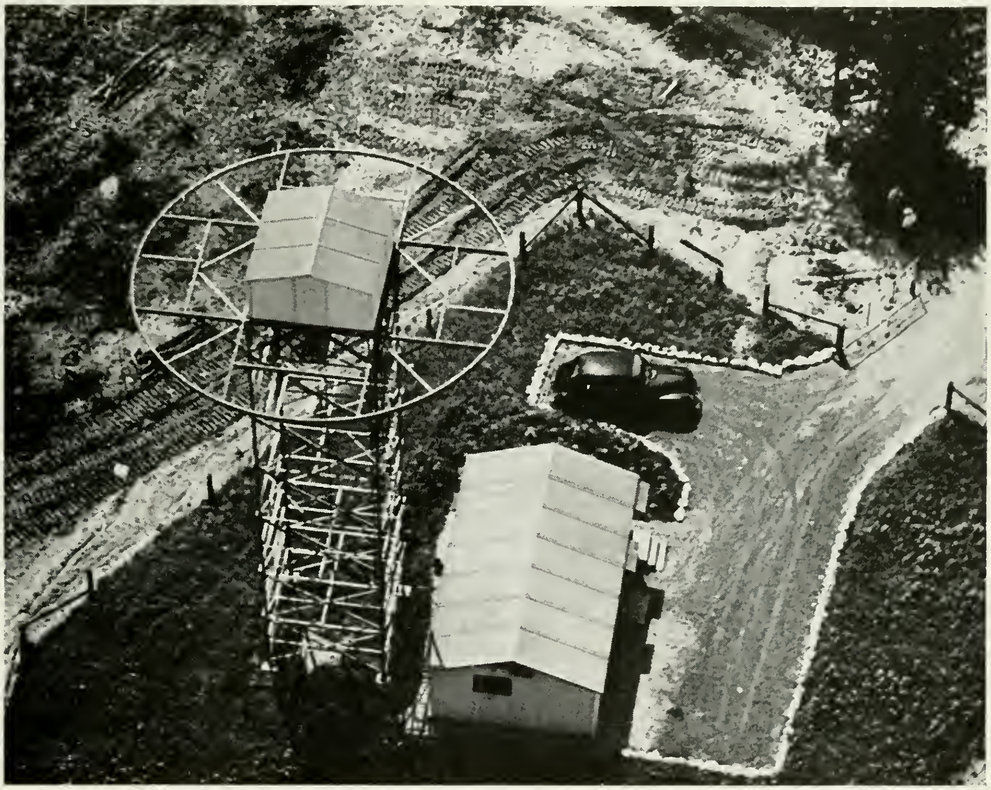
About 62,000 miles of teletypewriter circuits are used exclusively for gathering and disseminating weather information required for the safe operation of the airways. Weather information is gathered hourly from about 550 weather observation points. After it has been analyzed and interpreted, weather forecasts are broadcast over the teletypewriter lines to about 350 points for the use of the C.A.A. representatives, commercial airways companies, the military departments, private pilots, and others who may be affected. The rest of the private line teletypewriter circuits are used primarily for traffic control purposes, supplementing the interphone network especially for communications between non-adjacent traffic control centers.

As already noted, the interphone circuits are—with few exceptions—multi-station lines serving several airports, with a number of stations at each airport. These are located at airport control towers, C.A.A. communication offices, offices of the commercial air lines, Army and Navy locations, weather bureau offices, etc. Over the interphone lines is transmitted information inward to the traffic control centers from outlying airports about the movement of airplanes: that is, plans for projected flights, the time of arrivals and departures, the location of planes in the air, and other pertinent information regarding flights. Outward from the traffic control center are transmitted operating instructions to the C.A.A. and commercial airlines offices at distant airports, to be relayed by radio telephone directly to the planes in flight or on the ground at the airports.

THROUGH special switching equipment provided at intermediate points between traffic control areas, adjacent control centers can communicate directly with each other. In a few cases, direct private line telephone circuits are in service between adjacent traffic control centers.

The circuits furnished for the interphone network are carefully engineered, since transmission must be clear and distinctly understandable even under noise conditions which may prevail at many locations. As an additional precaution, the C.A.A. has specified that the key equipment at traffic control centers be so designed as to connect automatically with equipment for recording for future reference.

In addition to the interphone network, local private line telephone circuits are furnished to the C.A.A. in considerable quantities, where it has offices at airports. At traffic control centers these facilities are also connected into the same key equipment as the interphone circuits. At traffic control centers each of these local lines is usually equipped with a dial to enable the station to select the particular key equipment position desired and, if needed, arrangements can be made for connecting all of the local stations in conference. At many airports, local multi-station private lines are also provided which are not connected with the traffic control



An airplane view of a C.A.A. very-high-frequency radio station equipment. As in the case of the interphone circuits, each of the stations on these private lines is equipped with a loud-speaker which is normally actuated and a hang-up telephone set which, when used, automatically disconnects the loud-speaker.

The Associated Companies also provide many control channels from airports to unattended radio stations, usually three or four miles from the airport, at which various types of radio equipment are installed. Such stations may be combined radio telephone and radio telegraph equipment for communicating with planes in flight; radio range stations which emit directional signals to keep pilots "on the beam"; radio fan markers which transmit their signals vertically and give pilots a definite location on the airway; radio stations emitting directional signals for approach control and for blind landings; and non-directional radio transmitters emitting code signals used with radio compasses aboard planes for "homing" purposes.

The remote control facilities furnished the C.A.A. for operating these radio stations usually consist of circuits similar in transmission characteristics to private line telephone circuits, although in some situations circuits with wider frequency bands are needed. At present the System companies are providing about 300 control channels, aggregating about 1,250 circuit miles.

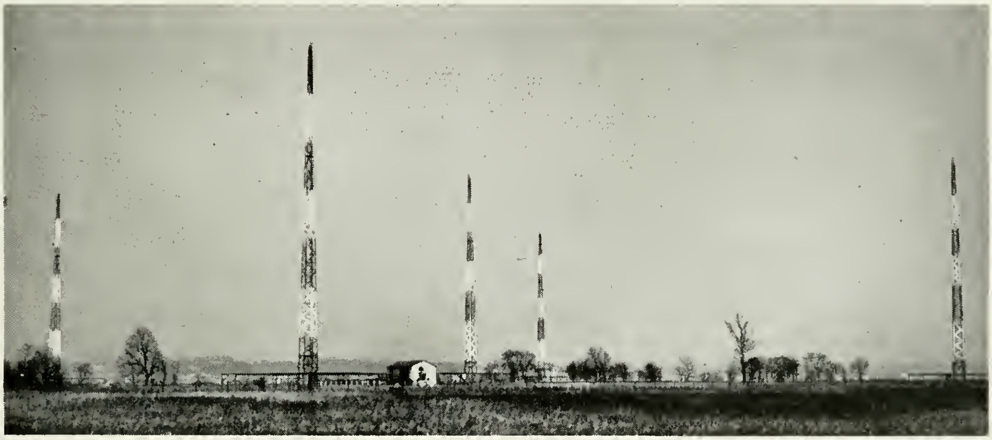
C.A.A. Procedures

THERE ARE NOW about 250 commercial airports and about 35,000 miles of Federal airways in the United States. There are, additionally, many military airports. About 150 of the commercial airports are equipped with airport control towers which exercise control of the airplanes on the ground at the airport and in flight within a few miles of it. For outbound flights, the airport control towers supervise all movements on the field, giving clearances for taking off and furnishing information about other air traffic which might affect the particular flight. Planes inbound to the airport usually call the airport tower while some distance away, and the tower assumes control and supplies information as to weather, landing conditions, when to land, run-way to use, etc. The C.A.A. is now operating about 105 of these airport control towers; 50 towers are handled by either municipal or military personnel; and the remainder of the commercial airports do not have sufficient traffic to warrant control towers.

In the control of the airplanes of the commercial air lines operating within the United States, C.A.A. airway traffic controllers do not deal directly with the pilots of the planes, but issue instructions to them through the dispatchers and flight superintendents of the air lines and receive information from the pilots through these officials. The C.A.A. traffic controllers do, however, deal directly through the C.A.A. radio stations with military planes and also with private planes in flight.

The C.A.A. owns and operates most of the facilities used to communicate with airplanes flying to and from foreign countries. Radio telephone and radio telegraph stations for this purpose are located at various points along the Atlantic, Pacific, and Gulf Coasts. Planes which operate into Canada and into Mexico are an exception to this general rule, since this traffic is operated on the same basis as local traffic within the United States as far as communications to planes in flight are concerned.

Radio telegraph is used almost exclusively for communicating with airplanes over the oceans some distance from the United States coast, because at present telegraph equipment of a given weight will furnish communication over a much greater distance than radio telephone equipment of comparable weight. Most of the large overseas planes, however, are equipped with radio telephone equipment for use in approaching the coast and in landing at or leaving airports.



A RADIO BEACON station of the C.A.A.

The Present Outlook

PRIOR TO THE WAR, commercial air lines had about 350 transport planes in domestic service, and there were about 25,000 privately owned airplanes. Various agencies have made estimates from time to time of the probable post-war development; and while these vary materially, the consensus anticipates that by 1950 there will be a ten-fold increase in commercial aircraft, and about 18 times as many private aircraft. It is also estimated that about 50,000 military aircraft will be in service at that time.

It is expected that in the early post-war period the commercial air lines in the United States should have close to 1,000 planes in operation, with a seating capacity of more than 36,000 passengers. The air lines have already purchased or have options on more than 400 new planes seating more than 23,000 passengers, and many of these new planes will be four-engine craft having speeds of about 300 miles per hour, enabling them to cross the continent on scheduled operations in from nine to ten hours. The new planes will also have greatly enlarged compartments for cargo, including mail and express. These new planes range from craft with a capacity of 14 passengers and a pay load of about 2,200 pounds for non-stop flights of 1,000 miles up to a 320,000 pound craft with six 5,000 horsepower engines carrying 204 passengers and a pay load of 68,000 pounds for non-stop flights of 3,000 miles at a cruising speed of around 340 miles per hour.

It is obvious that with aircraft of the size now foreseen, airports must be more commodious, and the number of airports needed will be greatly increased. It is also expected that the present 35,000 miles of Federal airways will have to be increased many fold.

The C.A.A. now has under consideration various plans for controlling air traffic in the years to come. It appears to be the view of both the C.A.A. and the commercial air lines companies that far more automatic features must be introduced in air traffic control than have been used in the past. Some war developments, such as radar, may have a wide application, and will insure greater flying safety in all types of weather. Technicians of both the commercial air lines and the C.A.A. also believe that, through combinations of wire and radio facilities, automatic block signals on airplanes are not impossible of attainment.

Whatever developments the future may bring in the size, speed, and range of airplanes, Bell System communication facilities will continue to play a major part in controlling their safe and orderly comings and goings over the nation's airways. The System has worked with the C.A.A. since its early days and small beginnings to keep its communications systems adequate to all requirements, rapidly though they have grown; and the System's components—Laboratories, Western Electric, Long Lines, Associated Companies, Headquarters staff consultants—give assurance that as the aviation industry strides ahead in the years to come, and the Civil Aeronautics Administration keeps pace, the necessary means of communication will be at hand.

It is not the desire of the management of the company to get all that it can out of the public; it is the desire of the management to get enough to make a fair return to those who own the property, to have a fair surplus left beyond that, and to make the financial structure of the system so stable that the business may continue indefinitely, that our securities may always rate as investment securities, and that we may continue to attract capital as needed for extension of the business.

From an address by the late Bancroft Gherardi, former A. T. & T. Vice President and Chief Engineer, published in the Bell Telephone Quarterly *for October, 1925*

Whatever the Type of Intelligence to Be Transmitted by Electricity, the Bell System Has Facilities to Carry It Swiftly to Its Destination

The Messages Go Through In Many Ways

H. I. Romnes

"We interrupt this program for a special bulletin." A switch to the newsroom, the clatter of teletypewriters, an excited announcer: "A Domei dispatch broadcast by Radio Tokyo states that the Japanese Government are ready to accept the terms enumerated at Potsdam . . . with the understanding . . ." So, on Friday, August 10, began an exciting drama at which the whole world had a front seat, thanks to modern communications.

"Flash! . . . the Japanese offer on its way to Washington has been received by the Swiss Government."

". . . bulletin . . . Our reply to the Japanese offer is on the way to Tokyo."

". . . a message from the Japanese Government . . . full acceptance of . . . unconditional surrender." It was President Truman with the long awaited words.

The drama continued to unfold before our ears and eyes. The arrival of the Japanese emissaries at Manila—the first landings in Japan—the signing of the surrender documents in Tokyo Bay: we got a word picture of each event *while* it was happening. A few hours later, photographs of these historic scenes, sent by radio and wire half way around the world, were in the newspapers to illustrate the stories sent by teletypewriter into every newspaper office. Never before had such an array of communication facilities been used to carry the news of a war's end to the four corners of the earth. What an astounding contrast with the War of 1812! Then, the news of the peace treaty traveled so slowly that the biggest battle was fought weeks after the treaty had been signed.

The development of communications could well be told by the history of such occasions: how long it took to get the news, how much news was obtained, how it was carried. For the same means available for the enactment of last summer's drama stand ready for our day-by-day communication needs, whether for inviting friends to an evening of bridge, bringing us beautiful music or the vivid play-by-play account of a ball game, or speeding the nation's business transactions.

In all these fields and in many others, the Bell System stands prepared to furnish the transmission path. The business goes far beyond that of setting up telephone connections. It embraces, in fact, the electrical transmission of many forms of intelligence: speech, a typewritten page, a picture. And it does it by many means: open wire, cable, carrier, radio—whichever is best fitted to do the job. How these various forms of information are prepared for electrical transmission, and how the various means used for transmission fit together to form a complete and flexible communication system, is a story of Bell System accomplishment from the telephone's early days to the present—and the future.

"Carried to the four corners of the earth" is a trite phrase, but significant. For each of the well-nigh countless ways in which intelligence is conveyed from one point to another involves a carrier of some sort. And in each case this intelligence is conveyed by changing some characteristic of the carrier. Or, to be technical, we vary or modulate the carrier according to the message to be sent—and in such manner that it may be decoded or demodulated at the receiving end. The American Indian used a smoke column as his carrier, and by modulating this into puffs could transmit a limited amount of intelligence. Today, a great deal of intelligence goes by mail: the paper itself is the carrier, which is modulated in appearance by a contrast of the paper's color with that of the ink or pencil with which the message is printed or written. In both cases the eye is the demodulator, and it decodes the message almost without conscious thought or effort.

In the telecommunications business, the electric current or wave is the carrier. It is modulated in various ways, depending upon the kind of information to be sent. The modulated current is then sent by wire, radio, or other media to its destination, where the intelligence is restored to its original form—whether that be speech, a picture, or something else. The character of the transmitting path does not depend so much on the *kind* of information to be transmitted as upon *how much* and *how quickly*.

Modulating the Carrier

The most common method of impressing intelligence on an electric current is by varying the strength of the current. The simplest form of this is to turn the current on or off; operations which may be used to transmit signals having pre-arranged meanings. For example, a subscriber to manual telephone service by lifting his receiver causes a current to flow in the line and light a lamp in front of an operator, telling her that a connection is desired. The line current conditions for this case are suggested by Figure 1A.

The teletypewriter is another form

of apparatus which uses *on* and *off* signals to convey intelligence; but now instead of transmitting *on* and *off* signals moments or hours or even days apart, several changes from one to the other are made within the fraction of a second required to send a single character. Much more intelligence is now being transmitted than in the first illustration, where current is simply turned on and off at relatively long intervals; in fact, words are being recorded at the distant point at the rate of 60 to 100 each minute. An intelligence-bearing electric current is created in this case by dividing the time required to transmit each character (about 1/6 of a second) into seven intervals and sending or interrupting a line current in each interval according to which character is to be printed at the distant point. In the first of these seven time intervals the current is off, and in the last it is on, to indicate the beginning and end of a character. The other five intervals determine the letter or character to be printed. For example, when the typewriter key for letter P is pressed, current is on during intervals 2, 3, and 5, and off during intervals 1 and 4. The line current carrying the word "PEN" may be represented as in Figure 1B.

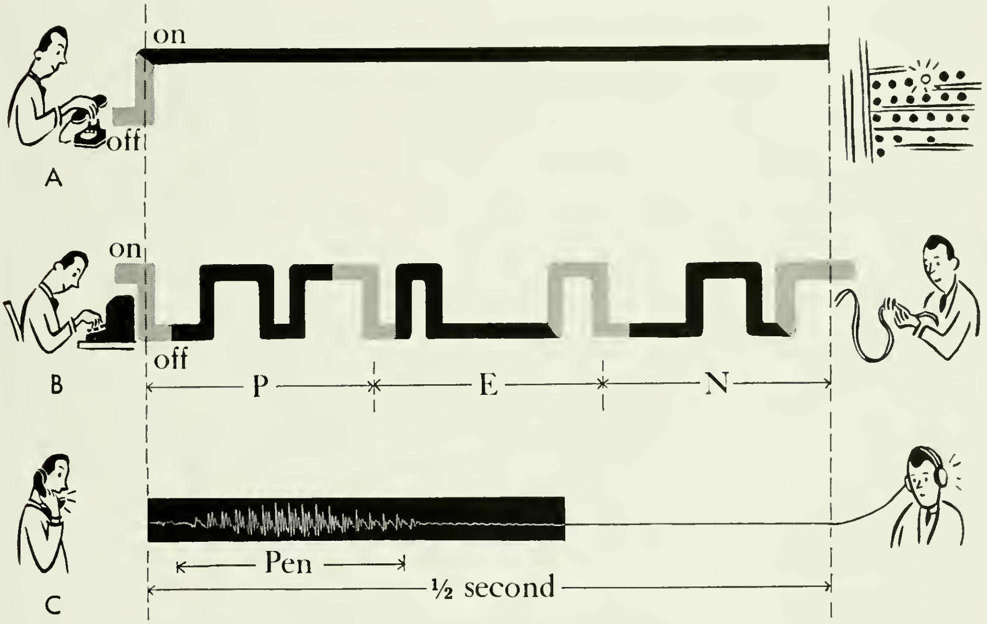


FIG. 1. The frequencies to be transmitted depend on how *much* intelligence is to be transmitted, and how *quickly*. These sketches illustrate how the frequencies may vary—from a very few per second for a simple line signal to nearly 50 per second for teletypewriter transmission and to several thousand per second for ordinary speech

A current bearing the spoken word "PEN" looks like the picture in Figure 1C. By comparison, we see not only that more words are transmitted than by the teletypewriter in the same interval—two to four a second—but by the peaks and valleys of the picture we might surmise that those words are accompanied by important little overtones that tell us whether it is Bill or John speaking, or whether Mary is displeased over our having "to work tonight." Current is given this speech-bearing shape by means of the transmitter, which is simply a sound-operated valve that allows more or less current to flow, depending upon the strength of the sound waves striking it. The resultant line current entering a receiver at the distant end of the line increases and decreases the pull of a magnet, causing the receiver diaphragm to move back and forth and thus create sound waves in the air which reproduce the original speech.

A comparison of the three line currents in Figure 1 indicates that the more intelligence to be transmitted in a given length of time, the more rapidly the information-bearing current must vary. A variation of current from a low value to a higher value and back again is known as a cycle. If such a cycle occurs in 1/100 of a second, then 100 cycles may be

A MODERN open-wire line. Arranged and fully equipped for C-Carrier operation, this line could provide nearly 80 telephone circuits and 40 telegraph channels. With the wires more closely spaced and equipped with J-Carrier, the capacity of the line could be made even greater transmitted in one second, and the varying current is said to have a frequency of 100 cycles. Telephone speech normally requires the transmission of frequencies from about 200 cycles to 3,000 cycles per second; that is, a band of frequencies about 2,800 cycles wide. The on and off signals of Figure 1A require very little frequency space. The teletypewriter signal of Figure 1B requires a frequency band of about 45 cycles. The transmission of music for radio network broadcasting uses frequencies up to about 5,000 cycles per second, and to reproduce faithfully such instruments as the trombone or such sound effects as the jingling of keys requires frequencies as high as 8,000 cycles and more.

This leads us to an important law of nature: *As the amount of intelligence to be transmitted in a given time is increased, the frequency band width required is increased in proportion.* The truth of this law can be further illustrated by describing and comparing the transmission of a picture by telephotography and by television.

A TYPICAL aerial cable line. When connected to a K-Carrier circuit on this route, a person talks over a voice channel in one of these two cables and hears words which reach him over a channel in the other

Telephoto and Television

In telephotography, a tiny beam of light about 1/100 of an inch across is focused on the picture to be transmitted. The light reflected from the illuminated spot on the picture is picked up by a photoelectric cell, which has the property of controlling the amount of current which flows in an associated line in proportion to the amount of light which strikes it. This spot of light is made to move across the picture and thus "scan" a strip or line of the picture 1/100 inch wide; it then scans the adjacent line and so on until every 1/100 of an inch element in the picture has had the light focused upon it. In effect, every square inch of the picture has been divided into 10,000 tiny elements, and the light beam focused on each one in turn. If the element being scanned at a given moment is white, a relatively large amount of light is reflected to the photoelectric cell which, in effect, closes a valve to reduce the amount of current flowing in the line. If the element is black, very little light is reflected and the valve opens to allow more current to flow. For intermediate shading, intermediate values of current flow in the line.

At the receiving end, a similar light beam moves across a sensitive photographic film, and exactly in step with the beam at the sending end. Passing through shutters under control of the line current, the receiving beam for each picture element is then made to vary in intensity exactly in proportion to the shading of the corresponding element of the picture being transmitted. Thus, element by element, in an interval of a few minutes, the whole picture is transmitted over the line. The exposed film is then developed and prints are made as in ordinary photographic work.

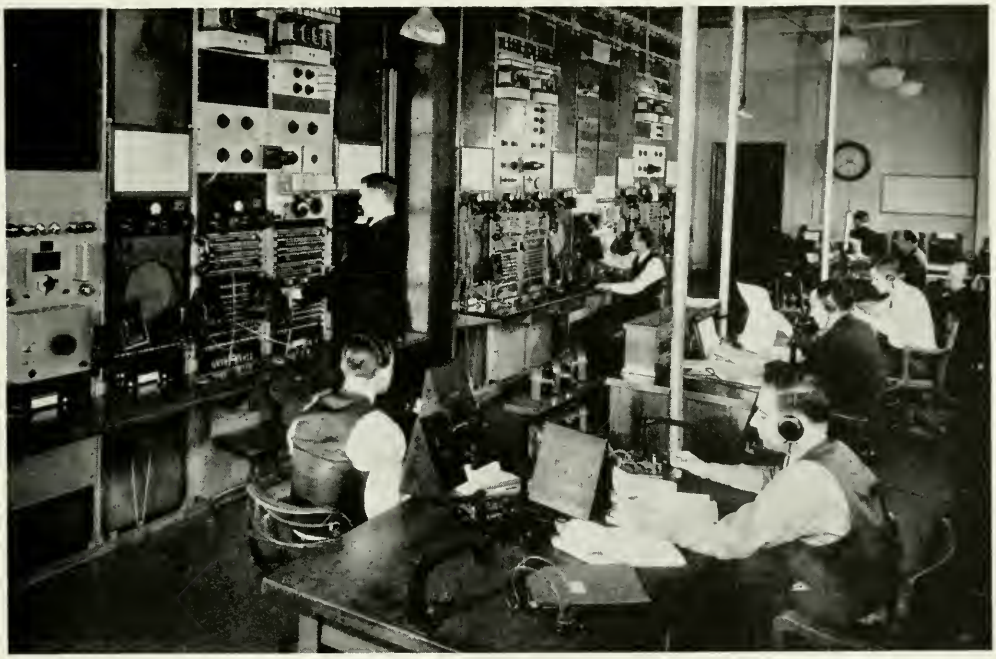
In a typical telephoto system, about 2,000 picture elements are scanned each second. Since one element may be white, the next dark, and the next white, the line current may have to go through one cycle for each two picture elements; that is, for 2,000 picture elements per second a frequency up to 1,000 cycles per second may be needed.

The television process is similar, but now in order to give a convincing sense of motion, 30 complete pictures per second are transmitted; and the receiving beam, instead of striking a photographic negative, impinges on a sensitive fluorescent screen to produce a visible effect. The rapid succession of complete individual pictures required to give a sense of motion is identical with what is seen on the familiar motion picture screen.

A 4-BY-6-INCH telephoto picture contains about 250,000 picture elements, and is transmitted in about two minutes. Each television picture of present-day standards likewise contains 250,000 picture elements, but it must be transmitted in 1/30 of a second. That is, in television we transmit picture intelligence about 4,000 times as fast as in telephotography. And, in accordance with the law previously stated, we would expect to need 4,000 times as much frequency space. Which is exactly the case, for the telephoto requires a 1000-cycle channel, as compared with one of about 4,000,000 cycles needed for television.

A communication channel may thus

range from a few cycles to several million cycles in width, depending upon how much intelligence is to be transmitted in a given length of time. To supply this variety of communication needs, the Bell System makes use of a wide variety of transmission facilities.



A Bell System control room, where radio program transmission networks are checked, and programs are switched on split-second schedule

In some cases, the communication channel having the desired frequency band is given the exclusive use of a pair of wires or a radio system. In other cases, wide frequency bands are transmitted and these are subdivided at the terminals into a number of channels, each of which has a width suitable for its intended use. This is done by means of the carrier system in which, for example, different telephone conversations normally occupying the band between 200 and 3,000 cycles are transposed to frequency bands of equal width in different parts of the frequency scale; these frequency bands are then stacked one above the other and transmitted simultaneously over a channel capable of handling the total band involved. At the receiving end, the individual bands are separated from one another and then restored to their normal frequency of 200 to 3,000 cycles.

The Open Wire Line

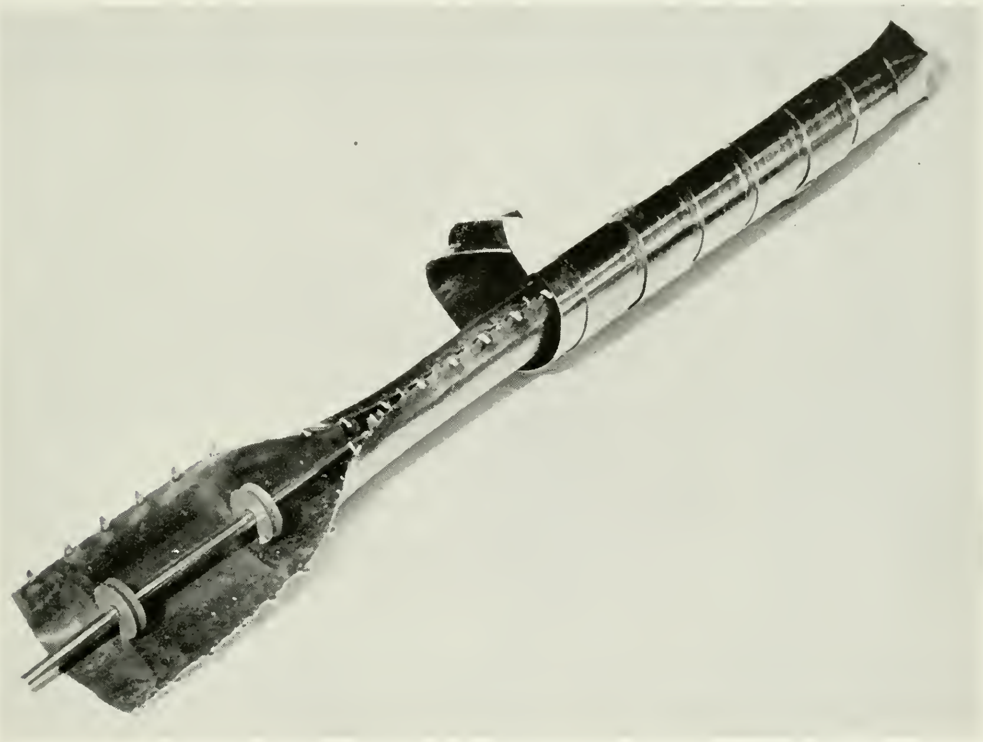
The earliest means for electrical communication was the open wire line, and it is still the most economical method of providing for relatively small numbers of telephone and telegraph circuits. More than 150,000 miles of open wire pole lines, carrying 2,600,000 miles of wire, are used in the Bell System for long distance transmission alone. Open wire, which is a common sight along roads in rural areas, consists of individual copper wires about ⅛ inch in diameter, strung six to twelve inches apart on crossarms mounted on poles. Where very few circuits are needed, each pair of wires transmits only the frequencies required for a single speech channel; say up to about 3,000 cycles. However, the frequency band below 200 cycles is not needed for speech transmission and may be used for communication channels which require only a narrow band of frequencies—such as those for teletypewriter operation.

As THE intelligence-carrying currents travel over wires, they become progressively weaker because of losses along the way ("attenuation" is the technical word), and as the frequency is increased the losses also increase. For the frequencies involved in the transmission of a single speech channel, the currents can travel over open wire lines for 150 or 200 miles or more before they are too weak to actuate a receiver satisfactorily. On circuits longer than this, amplifiers using vacuum tubes similar to those in a radio receiver are introduced to renew the strength of the speech currents.

A whole series of carrier systems has been developed to increase the number of telephone channels which can be obtained from a pair of wires. Each new system is designated by a letter, and by now the carrier alphabet has reached "L." One of the simplest of these carrier systems is the Type H, which is used to obtain one additional telephone channel on each of the existing pairs of wires. This system impresses on the wires additional frequencies between about 3,000 and 10,000 cycles, which are above those used by the telephone and telegraph circuits already operating on the wires. By means of fairly complex equipment in central offices, this added frequency band is divided into two parts, each about 3,000 cycles wide; one part is used for transmitting speech in one direction and the other for the opposite direction, the two being required to provide a two-way telephone circuit.

WHEN STILL MORE circuits are required on the line, particularly if more than about 75 miles long, it becomes economical to arrange the wires to transmit frequencies up to about 30,000 cycles by means of the Type C carrier system. Each pair of wires on which this system is used provides three telephone circuits in addition to the telephone and telegraph circuits already operating below 3,000 cycles. One or more of these 3,000 cycle telephone channels may be subdivided into 12 narrow channels, each one suitable for telegraph or teletypewriter operation. At intervals of approximately 150 miles along the route, amplifiers are required to renew the energy. At these points, the energy in the telegraph channel below 200 cycles is renewed by means of relays which operate on the weak incoming signal and close contacts to send out a full-strength signal; the telephone circuit between 200 and 3,000 cycles is amplified by means of a two-way vacuum tube repeater; the three C carrier channels transmitting in one direction are amplified as a group through a single amplifier and similarly the three C channels transmitting in the other direction through another amplifier.

In some cases, a larger number of circuits is required over an open wire line than can be obtained by the methods just described. The most economical method to obtain the additional circuits, especially where they are more than 200 miles in length, may be to apply the J carrier system. This gives 12 telephone circuits on each pair of wires in addition to the four already operating below 30,000 cycles. To do this, the wires are arranged to transmit frequencies up to about 150,000 cycles. With such high frequencies, the current is weakened very rapidly in traveling over the line, so that amplifiers are required at intervals of about 50 miles, but each of these amplifiers



A COAXIAL UNIT, opened to show its construction: central wire, insulating discs, copper tube interlocked at the seam, and outer layers of steel tape which keep the assembly intact, provide strength and flexibility, and help to keep separate the messages traveling over adjacent units. The placing of coaxial units in a cable is shown on page 215

An unattended repeater station on a coaxial cable line. It houses equipment capable of amplifying 1,500 conversations simultaneously, receives power for its operation over the coaxial cable, and will automatically notify the nearest attended station if trouble should develop in the equipment

handles 12 speech channels simultaneously. The J carrier system proved to be particularly valuable during the war period, when it was difficult to obtain copper for installation of additional wires. More than a half million miles of telephone circuits were obtained by this means.

Long Distance Cables

In sections of the country where sleet and wind storms are prevalent, or where the number of circuits needed is larger than can economically be provided on open wire, long distance circuits are provided by means of cable. The wires in such a cable are about the size of the lead in a mechanical pencil and are packed closely together within a lead sheath, insulated from one another by paper. In many long distance cables more than 600 such wires are contained in a single cable about 2½ inches in diameter. These cables may be hung on poles, may be placed in clay ducts under the streets of a city, or may be buried directly in the ground where the cable traverses rural areas.

Where the number of circuits to be handled through a cable is relatively small or where the circuits are less than about 75 miles long, the pairs in the cable are generally arranged to transmit frequency bands up to about 3,500 cycles. The frequency band above about 200 cycles is used for a telephone channel, or is subdivided into as many as 18 channels for teletypewriter operation. As in the case of open wire, the frequencies below 200 cycles are used for telegraph or other narrow-band channels. Electric currents transmitted over the closely packed fine wires of a cable are subject to much greater losses than in open wire. Where frequencies up to 3,500 cycles are to be transmitted, vacuum tube repeaters are required on cable circuits at intervals of 40 to 50 miles to renew their energy.

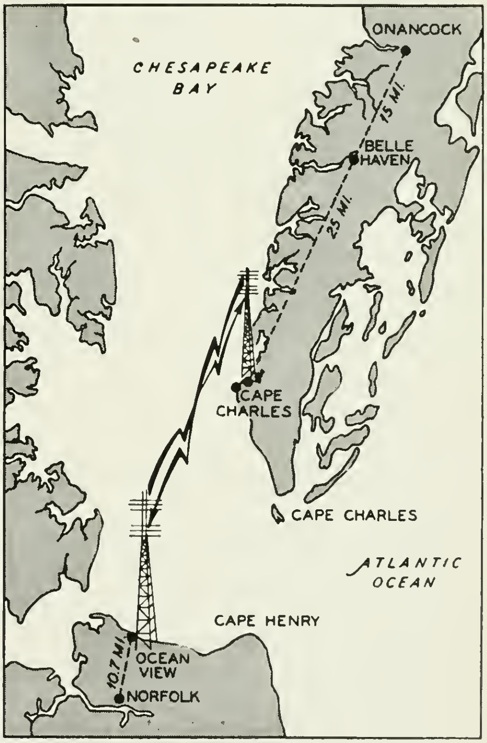
In situations where a fairly large number of circuits more than about 100 miles in length are required, each pair of wires in the cable can be arranged to provide 12 one-way speech channels by means of K carrier equipment, two pairs in separate cables being necessary to give 12 two-way telephone circuits. In this case, a frequency band of about 50,000 cycles is transmitted; and because of the high losses which the currents encounter at this frequency, repeaters which amplify the entire band are required at intervals of about 17 miles. This 50,000-cycle band can be subdivided in several ways to provide communications channels of various types. For example, it can be divided into 12 telephone circuits, one or more of which may be further subdivided into 18 channels suitable for teletypewriter operation. Or, frequency bands 5,000 or 8,000 or more cycles wide for the transmission of music for network broadcasting may be obtained by using the space normally occupied by several telephone channels.

The K carrier system has been widely installed in the Bell System since its introduction in 1938, and has also been an important aid in reducing the need for copper during the war period. By its application, about eight times as many long distance telephone conversations can be carried over the same number of wires as by previous methods.

Coaxial Cables

THE NEWEST METHOD of providing communications channels in large quantities and over long distances is the coaxial cable. The coaxial unit consists of a copper tube a little larger than a lead pencil, through the center of which runs a single wire held in position by means of insulating discs. Six or eight of these tubes may be contained in a single lead sheath, which is generally placed underground. Each of these coaxial units is capable of transmitting frequency bands many million cycles wide. Because of the high frequencies used, the currents are subject to extremely large losses and, therefore, amplifiers are required at intervals of five or eight miles when frequencies up to 3,000,000 cycles are transmitted, as in the present system.

This system (Type L carrier) can handle about 500 simultaneous telephone conversations, transmitting in one direction over one coaxial unit and over another unit within the same cable for the opposite direction. This is a "lot of eggs in one basket," so spare coaxial units equipped with amplifiers stand ready at all times to be automatically switched in, in place of the working units in case of an interruption. In a cable having



K-CARRIER with seven-league boots. This diagram illustrates how carrier telephone circuits make a 25-mile radio hop between Cape Charles and Norfolk, Va., thereby avoiding many miles of circuitous land travel eight coaxial units, which will be a common arrangement, about 1,500 telephone channels can be provided over six units, with two units used as standbys. Each of these telephone channels is about 3,500 cycles wide, and can be further subdivided into as many as 18 narrow band channels for teletypewriter operation. Or, the frequency bands of several of these telephone channels can be used together to form a wider band channel for the transmission of music for network broadcasting. Truly, a flexible and amenable messenger.

A UNIQUE feature of the coaxial cable system is that it can handle a frequency band wide enough for television. With present arrangements, this involves using the entire frequency band provided by one coaxial unit for a television transmission channel, while other units in the cable take care of telephone needs. In the future, with amplifiers placed at shorter intervals to permit transmission of wider frequency bands, the simultaneous transmission over a coaxial unit of hundreds of telephone conversations and a wide band for television will be possible. Or the wider band may be used for the transmission of television in color, if that should be desired. It is expected that the coaxial cable will find wide usage in interconnecting the many television broadcasting stations which are now planned for operation.

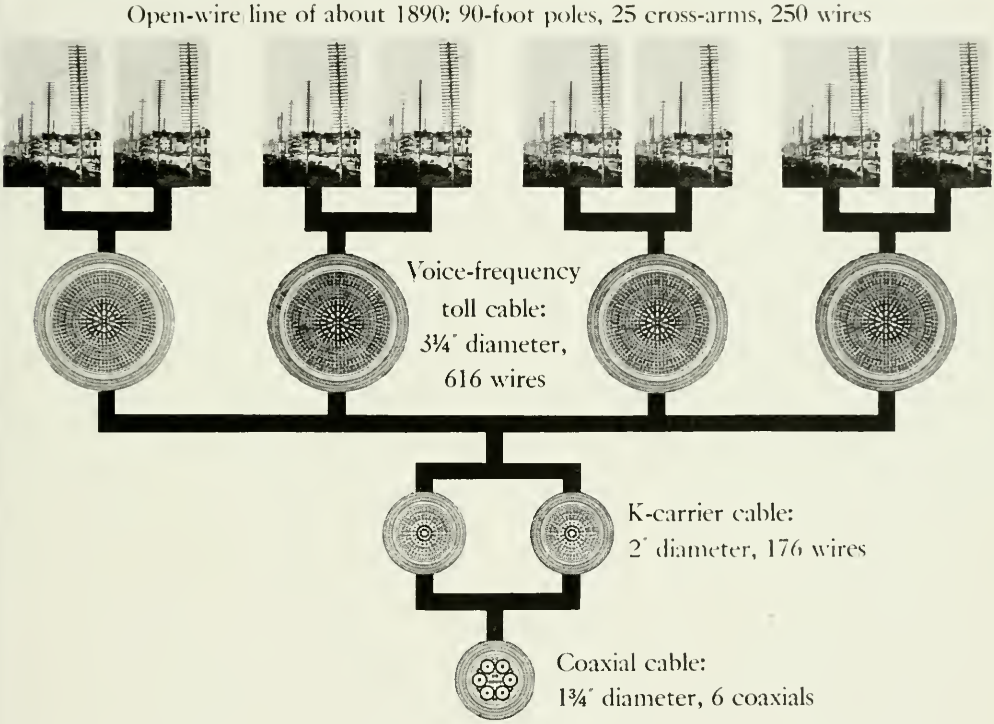
The Bell System is in the midst of a large coaxial cable installation program. Coaxial cables are now in operation between Stevens Point and Minneapolis, between New York and Philadelphia, and between Atlanta and Jacksonville; and before the end of the year will be in operation between New York and Washington. By the end of 1945, construction will be well under way on coaxial cables extending from New York as far west as Dallas, and by the end of 1946 coaxial cables to Los Angeles will be nearing completion. Plans have been made for additional coaxial cables west from Washington to Chicago and from Chicago to New Orleans, with later extensions to such points as Kansas City, Omaha, and Minneapolis, to Cincinnati and Louisville, and northward along the Pacific Coast. All together it is expected that there will be nearly 7,000 route miles of such cables in operation by 1950.

Radio

THESE extraordinary advances in wire transmission have been achieved through changes not only in the form of the conductor itself but in the various ways of multiplying the signal-carrying capacity of the conductor. They are the result of long continuing and specially directed research and development.

Paralleling the development work on various forms of wire transmission, the Bell System has for more than 30 years been developing another medium of transmission: radio. The first commercial radio telephone circuits in the Bell System were between Long Beach and Catalina Island, Cal., placed in service in 1920, and between New York and London, placed in service in 1927. Since then, many additional radio telephone circuits have been opened, so that now every country in the world having 75,000 telephones or more has been brought within voice range of this country.

Most of these radio telephone systems are used for a single speech channel. However, many of the overseas radio facilities now handle frequency bands about 10,000 cycles wide, which are subdivided into two or three telephone circuits. Radio has also been arranged to handle 12 telephone channels simultaneously. Such a system is used across Chesapeake Bay near Norfolk, a distance of about 25 miles, to avoid carrying telephone circuits by wire around this body of water, a distance of some 400 miles. Also, radio is used to provide telephone service to ships at sea and to vessels in harbors and near the coast. The Bell System is providing telephone service to motor vehicles and has announced plans to make this service available in all of the principal cities of the country. When severe storms damage wire lines and isolate communities, portable radio systems are available to provide a few emergency telephone circuits until normal service can be restored.


Open-wire line of about 1890: 90-foot poles, 25 cross-arms, 250 wires
Voice-frequency toll cable: 3¼″ diameter, 616 wires
K-carrier cable: 2″ diameter, 176 wires
Coaxial cable: 1¾″ diameter, 6 coaxials

Open wire—voice frequency cables—K-Carrier cables—coaxial cable: each shown in the quantity needed to provide about 1,000 circuits. Thus may be illustrated the continual trend toward smaller and fewer wires

Another interesting use of radio is the radio relay system, a Bell System trial of which is now being prepared between New York and Boston. In this system the radio energy will be transmitted at frequencies of billions of cycles in narrow beams from one relay station to the next, the stations being located on high points of ground at intervals of about 30 miles. These relay stations will receive the greatly weakened radio energy from the preceding station and amplify it for transmission to the next (see illustration on page 153). Thus the principle of inserting amplification in the circuit at frequent intervals along its length, which has for years been applied in long distance wire lines, is now being adapted to radio. The radio relay system will be arranged for the transmission of a frequency band several million cycles wide which can be used as a whole for transmission of television or can be subdivided into a number of telephone circuits.

Looking Ahead

THE BUSINESS of the Bell System is to provide means for the transmission of intelligence: speech, music, pictures, typewritten words, or whatever its form—and to do it quickly, clearly, and at the lowest possible cost. Over a period of more than half a century, the System has created a physical plant for this transmission which has no counterpart in dependability, scope, and flexibility. The System's scientists and engineers are constantly searching for better ways of doing the job. They have pioneered in transmission developments which have revolutionized world communications.

One example of the results of their efforts has been the progressive reduction in the size of conductors used for long distance transmission: from large wires on poles to small wires in cables, made possible by the vacuum tube amplifier; to a multiplicity of messages on the same wires through the development of carrier systems; to a copper tube with a single wire down its center carrying hundreds of simultaneous conversations or a moving picture; finally to the elimination of the metal conductor entirely by the use of radio waves focussed in narrow beams. One method does not supplant another; each has its place and all share in providing service in a comprehensive communication system.

The coming years will no doubt bring requirements for new means or new methods of transmitting intelligence by electricity. The sure prospect that those requirements will be met, that the nation's needs will be foreseen and the means and methods will be ready to serve, rests on the same research which has brought the System's transmission art to its present high development and the same engineering ability and manufacturing capacity which have built today's vast telephone plant.

Bell Telephone MAGAZINE

Public Library
Kansas City, Mo.

RADAR:

Radar and Bell Laboratories · Mervin J. Kelly

Radar: A Story in Pictures

Radar and Western Electric · Frederick R. Lack

The Bell System's First Order of Business · Harold S. Osborne

Dual Telephone Service Ends in Philadelphia · Peter L. Schauble

erican Telephone & Telegraph Company · New York

Bell Telephone Magazine

Winter 1945-46

Radar and Bell Laboratories, *Mervin J. Kelly*, 221

Radar: A Story in Pictures, 256

Radar and Western Electric, *Frederick R. Lack*, 283

The Bell System's First Order of Business
Harold S. Osborne, 295

Dual Telephone Service Ends in Philadelphia
Peter L. Schauble, 311

"The ideal and aim of the American Telephone and Telegraph Company and its Associated Companies is a telephone service for the nation, free, so far as humanly possible, from imperfections, errors, or delays, and enabling anyone anywhere to pick up a telephone and talk to anyone else anywhere else, clearly, quickly and at a reasonable cost."

A Medium of Suggestion & a Record of Progress

Published for the supervisory forces of the Bell System by the Information Department of
AMERICAN TELEPHONE AND TELEGRAPH CO., *195 Broadway, New York 7, N. Y.*
WALTER S. GIFFORD, *Pres.;* CARROLL O. BICKELHAUPT, *Sec.;* DONALD R. BELCHER, *Treas.*

Who's Who & What's What *in This Issue*

Historians of World War II will record that the armed might of the Allied Nations had laid Italy and Germany prostrate and was closing in on Japan for the kill before Manhattan Project's atomic secret burst on the world; and they may attribute those military successes in no small part to the advantage the Allies possessed in radars of many kinds, vast numbers, and superior performance.

The Bell System had a large and important share in the development and production of radar in this country. How large, how important, is now recounted comprehensively for the first time by two men who speak with authority and from an intimate knowledge of the radar program:

Mervin J. Kelly

Mervin J. Kelly, executive vice president and a director of Bell Telephone Laboratories; and Frederick R. Lack, vice president and a director of the Western Electric Company and head of its Radio Division.

Joining in 1919 the Engineering Department of Western Electric—which became Bell Laboratories in 1925—Dr. Kelly has devoted the years since to research in electronics and to the development of many types of thermionic devices. He was appointed director of research of Bell Telephone Laboratories in 1936, and in 1944 he was given additional responsibility as executive vice president. During World War II he devoted practically all his time and energy to the Laboratories' multitudinous war projects, and was in particularly close touch with the progress of radar.

Frederick R. Lack

Mr. Lack joined the Manufacturing Department of Western Electric in 1911. A year later he transferred to the Engineering Department, and to it he returned in 1919 after overseas service in World War I. Thereafter his work was concerned broadly with the development of several aspects of radio telephony, including the use of piezoelectric crystals for stabilizing radio frequency generators, and vacuum tubes for various types of radio telephone application.

Mr. Lack left Bell Laboratories in 1938 to return to Western Electric as commercial manager; and in 1942 he was elected vice president and was appointed manager of the Radio Division. At the Government's invitation, he served for some months during 1942 and 1943 as director of the Army and Navy Electronic Production Agency.

IN THE past five years this MAGAZINE has recorded some of the many ways through which the Bell System contributed to this country's share in victory over the Axis Powers. The contributions were major and the effort was extreme—as witness, for example, this issue's articles on radar. But now "the war is over" to most people—including a good many who want telephone service, haven't been able to get it, and don't see why not. So, having performed near-miracles of many kinds under the stress of war, the System recognized that to accomplish still other miracles became its first order of business under the stress of peace; and HAROLD S. OSBORNE submits a report on "how we're doin'," and how we are doing it. He joined the A. T. & T. Co. in 1910 as an engineer in the then transmission and protection department, and has since been transmission engineer, operating results engineer, plant engineer, assistant chief engineer, and—since 1943—chief engineer of the present Department of Operation and Engineering. He was co-author of "More and Better Telephone Service for Farmers," which appeared in the Winter issue of this publication a year ago.

HAROLD S. OSBORNE

ELIMINATION of the Keystone Telephone Company from the Philadelphia scene does indeed mark the end of an era—but an era for which there need be no regret, no nostalgia for the good old days. The days of competitive telephone service were not good: duplicative service was always uneconomic and a nuisance. And since the country finally got rid of it, for all practical purposes, at Philadelphia last September 17, it is PETER L. SCHAUBLE who tells how its end came about. For he is vice president of the Bell Telephone Company of Pennsylvania in charge of the Public Relations

PETER L. SCHAUBLE

(*Continued on page 255*)

Index to Volume XXIV

AN INDEX to Volume XXIV (1945) of the BELL TELEPHONE MAGAZINE may be obtained upon request to the Information Department of the American Telephone and Telegraph Company, 195 Broadway, New York 7, N. Y.

AIR EXPRESS was the fastest method of getting telephones to certain areas where shortage of instruments alone was delaying service to waiting customers—so by air express they went. See "The Bell System's First Order of Business," page 295

The Bell System's Development and Huge Production of Many Kinds of Radars Rank High as a Contribution to The Victories Over the Axis Powers

Radar and Bell Laboratories

Mervin J. Kelly

RADAR—RADIO DETECTION AND RANGING—in the importance of its contribution to victory ranks high among the new weapons of World War II. It employs radio waves for the detection and accurate location of objects, fixed or moving. It can see farther than the eye, even under conditions most favorable to vision. It sees equally well by night and by day. Neither smoke, fog, clouds, nor rain diminishes its range or its resolution of objects.

Radar refers to no single instrument: it is a synthetic word which describes a function. Indeed, an individual radar set may weigh only a hundred pounds, have the size and shape of a small bomb, and be suited to installation in a fast airplane; or it may be a vast assemblage of equipment mounted in a truck and several trailers, have a giant antenna structure, and require a whole company of soldiers to operate it. It may be a three-ton equipment disposed above and below the deck of a battleship, or it may be two or three water-tight boxes on the deck and a small antenna on the mast of a landing barge. While radars assume this great variety of form and size, they are all governed by the same radio principles and employ the same electronic and communication techniques. Their functioning elements have, in common, electron tubes in large number and great variety, interconnected by most complex communication-like circuits.

All radars embody a transmitter, an antenna, a receiver, and a video system. The transmitter generates the radio energy as pulses of suitable form and power. The antenna both radiates energy in a preferred space pattern and picks up energy "echoed" from the objects viewed. The receiver accepts from the antenna the returning pulses of energy and amplifies and reshapes them in such a way that the video system can display the echo information in a variety of visible patterns and supply it in electrical form for the direction of missiles.

In consequence of its ability to see, radar played a great and increasingly important role in the conduct of the war on land, at sea, and in the air. It has brought about profound changes in the pattern of warfare. Surprise has always been one of the most important elements in attack. In the past, surprise has been achieved by the deployment of forces in the darkness of night or under a covering of fog, cloud, or smoke. The early warning of enemy approach afforded by our ever-improving radar equipments and the increasingly effective techniques for their use deprived the enemy of the advantage of surprise attacks.

Radar not only sees; it can also measure distance and angles. Radar continuously measures the distance to a fixed or moving object and the angles defining the direction of the object with such exactness that this location information can be used for fire control of guns, directing of torpedoes, or dropping of bombs.

A new instrument of war, when equally developed and applied by the combatants, changes the style of war but is not likely to become a decisive element in victory for either side. However, when one of the combatants moves more rapidly in the development of the new instrument and makes broader and more rapid use of it in his strategy of war, he then can make it an important and perhaps determining element in his victory. This, indeed, is the pattern of radar's application in World War II.

In the years immediately before the war, radar was conceived and had its pioneering development in the military laboratories of our country, England, Germany, and perhaps Japan.

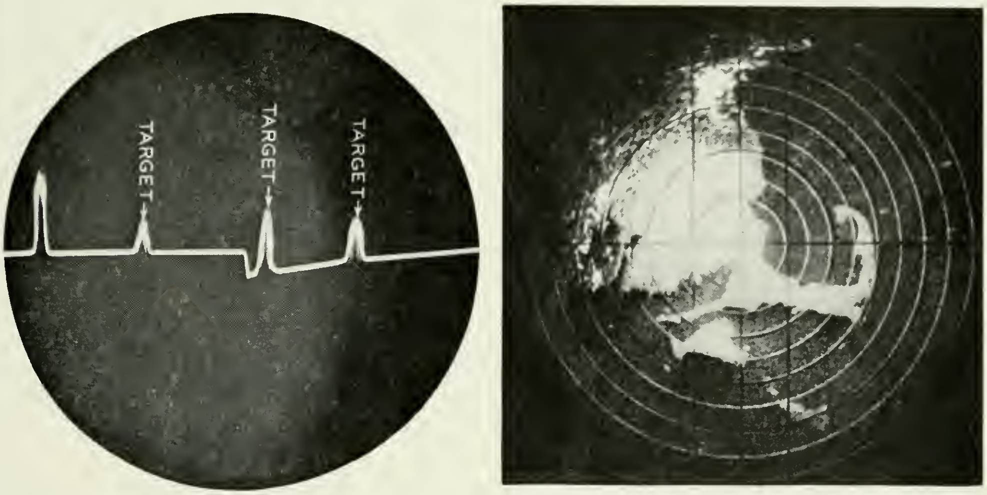
At the war's beginning, the radar technologies of Germany, England, and our country were at about the same level of development, while Japan's was decidedly inferior. As the war progressed, we advanced radar science with much greater speed than did our enemies. We applied it to almost all sectors of warfare, and supplied our armed forces with a tremendous volume of specialized equipments suited to a wide variety of applications. Our armed forces made immediate and broad application of this radar equipment and modified their strategy of war to great advantage as they increased their facility in the use of this new weapon.

Our enemies, advancing the technology at a slower pace, made available to their armed forces a substantially smaller volume of equipments which were more limited in variety and of a lower level of effectiveness.

As the war progressed, radar, therefore, became an instrument of increasing advantage to us. It shortened the war and made our victory possible at a lower cost in lives and material.

Radar attained this high level of importance to victory because our country concentrated on it a gigantic effort in research, development, design, and production. In 1940 less than $25,000,000 was expended on technical and production effort for radar. Radar effort in all its phases expanded rapidly throughout the war, and in 1945 was at an annual level of more than $1,000,000,000.

There have been many technical workers in this field both in England and in this country. They have enjoyed full interchange of technical information, so that each could use the information of the other as well as his own. In particular, Bell Laboratories worked very closely in this field first with Army and Navy laboratories and later also with the Radiation Laboratory at Massachusetts Institute of Technology; and in all cases there was freest interchange of technical material.



RADAR ECHOES are displayed on an oscilloscope screen. The "A" presentation (left) shows the distance to three targets; the "PPI" (right) gives a map-like picture of the area below an air-borne radar—here the Cape Cod area of Massachusetts

The laboratories of the Services were working in radar through the 1930s. When, in 1940, the national defense program was materially stepped up, the National Defense Research Committee set up the Radiation Laboratory at Massachusetts Institute of Technology to undertake a broader program of Government-sponsored research than had been possible with the limited facilities of the Services' laboratories. This organization built up its research staff and facilities and carried out a most important program of research and development work, particularly in the micro-wave field.

The Bell System played a larger part in the radar program, from research through production, than any other industrial organization. Through its manufacturing company—the Western Electric—it produced about half of all the radar made in the United States; and through its research organization—the Bell Telephone Laboratories—it carried out a comparable portion of the research and development programs.

Throughout the preparedness and war years, the Laboratories, with a continuously expanding program, gave almost half of its effort to radar science and technology. It expended approximately $85,000,000 in its research, development, design, and early-model production effort.

The Western Electric Company produced equipments resulting from this effort in a volume of approximately $900,000,000, and there was production of radar facilities by others, from designs completed in Bell Laboratories, in volume of at least $100,000,000.

Radar's Early History

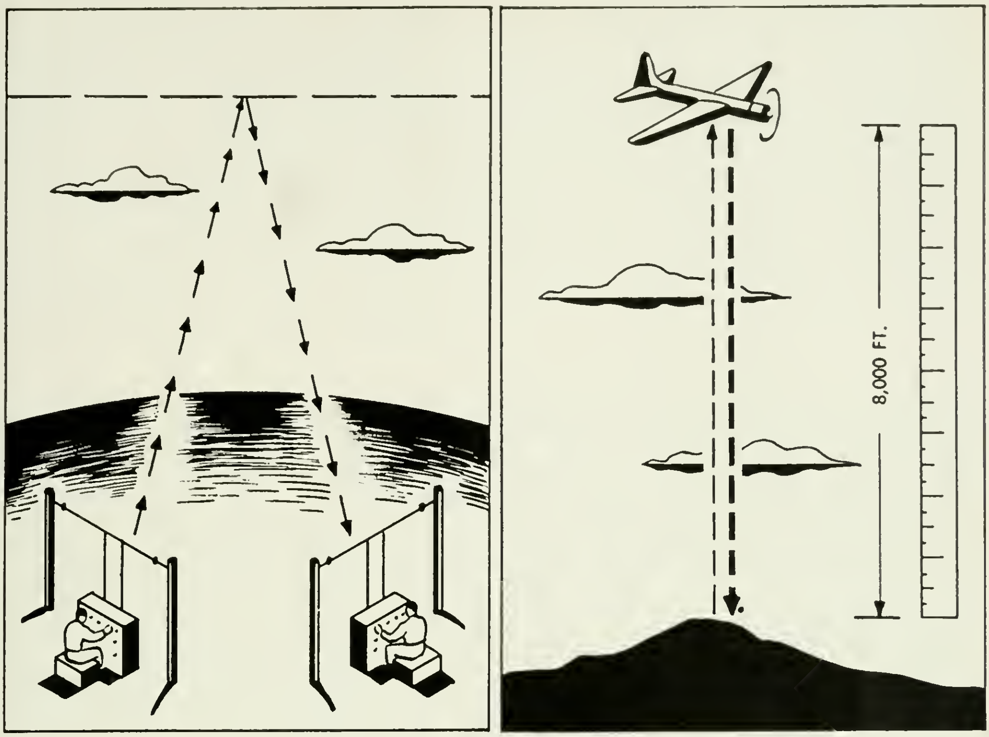
RADAR, THROUGH ITS receiver and video system, determines the distance to each object by measuring the time required for a pulse of radio energy generated by its transmitter to go from its antenna to the object and to return. (The pulse is reflected or "echoed" by the object.) The object's direction is determined by observing the direction in which the antenna is pointing when it receives the maximum energy from the object. (The antenna points directly at the target when it receives the maximum energy return.)

RADAR may well be considered a type of radio communication. It is like broadcasting in that it is one-way transmission of intelligence. It is unlike broadcasting in that it gathers intelligence from its surroundings rather than giving it out. The intelligence gathered is the distance and direction of objects within the range of the radar.

Man has long had the desire to see in darkness and through fog. But the satisfaction of this desire had to await the development of radio technology to a degree first reached at the beginning of the 1930s, when the techniques and tools essential to the pioneering development of object location with radio waves were at hand. We now know that those engaged in military radio research in Germany, England, and our own country turned their attention to this development at about the same time.

Many elements of new technology were necessary. Probably the most important were the extension of the useful radio spectrum to wave lengths at least as short as two or three meters; advances in electronic and circuit techniques to make possible generation of extremely short pulses of radio energy at high levels of power; and accurate measurement of time intervals as short as a few hundred-millionths of a second.

Making use of these new elements of technology as well as of established communication and electronic art and science, our Army and Navy laboratories made remarkable progress during the 1930s in evolving research models of object-location equipment using radio waves. Behind the cloak of secrecy essential to military research, they studied various radio methods of object viewing, and selected the preferred system by the middle of the 1930s. They then worked intensely, within the limits of their resources, to improve and perfect the system selected. The Naval Research Laboratory pointed its effort to equipments for use on ships,



Radar development by Bell Laboratories was greatly facilitated by earlier experience with such projects as measurement of the height of the ionosphere (left), and the radio altimeter (right), both employing the echo technique

---

while the Fort Monmouth Signal Corps Laboratory directed its attention to equipments for army ground forces.

On July 13, 1937, at the invitation of Commander (now Captain) W. G. Ruble, some Bell Laboratories engineers, accompanied by Commander (now Commodore) J. B. Dow, visited the Naval Research Laboratory at Anacostia, and were shown the radar work which was in progress there under the immediate direction of Dr. A. H. Taylor. After this visit, as is Bell Laboratories' practice at the preliminary survey stage of any new research program, an analytical study and appraisal were made. A selected group of scientists and engineers made an analysis, as complete as was possible with available information, of object location through the use of radio waves. This included re-radiation (echoing) from targets, and the advantages and limitations of different ranges of the radio frequency spectrum. The Bell Laboratories group returned to the Naval Research Laboratory on November 5, 1937, to witness a demonstration of improvements which had been made in the meantime and for further discussions with those working on the project.

The men at the Naval Research

Laboratory were working with wave lengths in the neighborhood of one to two meters. They were transmitting from a directional antenna short pulses of radio energy in this wavelength range. They had already developed an ingenious circuit for using the same antenna for sending the radio pulses and receiving their echoes reflected from objects in the vicinity.

Because of fundamental properties of the wave lengths employed, their system had only limited—though important—military value. It was adequately effective for military use only against airplanes flying at relatively high altitudes. At the wave lengths employed, it is not possible to get enough energy on and immediately above the surface of the sea to detect ships or low-flying planes with a certainty and over distances essential to military value.

In spite of these restrictions, which are fundamental to the wave lengths employed, the Naval Research Laboratory's object location system was a most important development. It incorporated fundamental principles, essential circuits, and electronic techniques which were to characterize the enormous radar developments of the following years. Although, as the war progressed, radars using shorter waves came to play a larger part in our radar warfare, this early system established in wave length and in circuit arrangement the pattern for the large number of equipments which were used by our naval ships of many classes throughout the war for the longest-range detection of enemy planes.

The Naval Research Laboratory's scientists and those from Bell Laboratories recognized the limitations of the wave lengths employed and were in agreement that considerably shorter wave lengths were essential to the location of low-flying planes and of objects, such as ships and submarines, on the surface of the water. They also recognized that, with materially shorter wave lengths and further advances in circuit and electronic techniques, beams of radio energy could be made sufficiently pencil-like in nature (similar to a searchlight beam) to distinguish objects separated by small distances, such as planes flying in formation, and to measure the exact distance and direction to one of them. Shorter wave lengths could extend the area of radar's application down to the surface of the sea and, through adequate resolution and accurate measurement of object position, make radar direction of gun fire possible. Shorter radio waves must be used in radar!

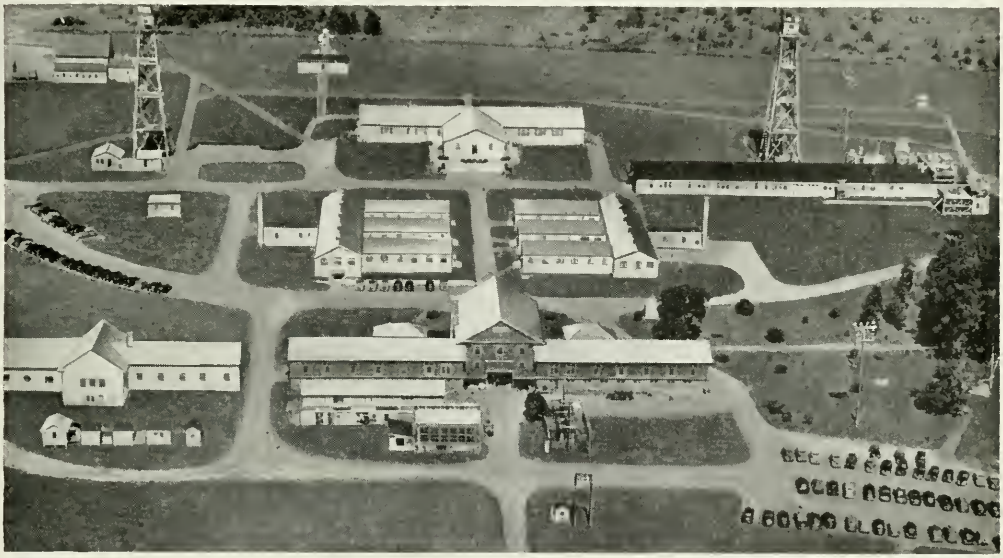
Bell Laboratories' First Radar Project

There was already in progress at Bell Laboratories a research program directed at the extension of the radio spectrum to shorter and shorter wave lengths. This was a part of the Bell System's program of extending the scope, improving, and lowering the cost of communication through new applications of science.

The group at Bell Laboratories who had been brought into the radar secret believed that communication circuit techniques and new electronic devices then available from this research program were adequate for the initiation of explorations in radar to a wave length as short as perhaps 40 centimeters (16 inches).

After discussions between Bell Laboratories' management and those responsible in the Bureau of Ships, it was agreed that the Laboratories, because of its knowledge and experience in this field, could be of most service to the radar development program in extending radar to shorter wave lengths.

The radar excursion into the shorter wave-length area, which even for communication was in the research stage, was of such a pioneering and speculative nature that it was not possible to predict that any useful military equipment would result. Under the then established rules of Navy development contracts, it was not practicable to contract for such a highly speculative research program. However, all concerned recognized the importance of such an investigation.



RADAR DEVELOPMENT in the Bell System was centered at the Whippany plant of Bell Laboratories. Rapid wartime growth required construction of many temporary buildings

Because of its potentialities for results of importance to our country's preparedness program, and because of the intimate relation of Bell Laboratories' centimeter-wave radio research to the centimeter-wave radar problems, the American Telephone and Telegraph Company authorized the Laboratories to proceed with the investigation. This made it possible for the Laboratories to carry the radar excursion into the shorter wave-length area to a place where, if successful, contracts could be entered into with the Navy for a development to specified requirements.

The allocation of funds that made it possible for Bell Laboratories to initiate at such an early date a research program extending radar into the centimeter range started a chain of events which was to be of profound significance in our country's naval victories and in its radar development programs.

As will later be revealed, Bell Laboratories' radar activities in the 40-centimeter area which resulted from this research were of importance not only in making the first fire-control radars available but also in bridging the gap between the early radar work of our Army and Navy laboratories and the ten-centimeter and shorter wave-length radar programs which were initiated in 1940.

HAD THE LABORATORIES *not proceeded immediately with this research —carried out without the restrictions of a specifically directed contract— fire-control radar would probably not have been in production and installed on some of the ships of our fleet by the time of the Japanese attack on Pearl Harbor. The night victories of the South Pacific in the winter of 1942–1943 which our outnumbered fleet won through radar search and radar-directed gun fire might well have been defeats.*

Soon after the November 5, 1937, visit to the Naval Research Laboratory, work was begun in Bell Laboratories on its centimeter radar program. In May, 1938, the research was moved from its New York location to the laboratory at Whippany, New Jersey, the better to maintain secrecy and to facilitate object location experiments.

Throughout the remainder of 1938 and in the Spring of 1939, the Whippany group continued its intensive program of application of centimeter waves to radar. It received support in essential research and development from various component groups in Bell Laboratories. By early Summer of 1939 the first research model of a complete radar equipment operating at about 60 centimeters had been completed and had been given, as far as possible at Whippany, object location tests, principally against planes. To obtain better information about its performance under location conditions equivalent to those on a ship, a bungalow to house the equipment was obtained at Atlantic Highlands on a bluff whose height above the water approximated that of an antenna installed atop a battleship.

This site proved so satisfactory for tests of ship-borne radars that Bell Laboratories later built a test house on land adjacent to the bungalow. It was in use continuously throughout the war in testing early research and development models. These tests were frequently witnessed by radar scientists and interested military personnel of our country and our Allies.

The usual sequence of events on the development model of a new equipment was to complete its assembly and "tuning up" at Whippany, then to make performance tests and adjustments at the Highlands test house. When the equipment was found to meet the Navy's performance requirements, it was taken to the Naval Research Laboratory for final evaluation.

Successful performance tests of the new equipment were made here in June, 1939. At that time sharp and stable echo signals were obtained from nearby ships, from buildings on

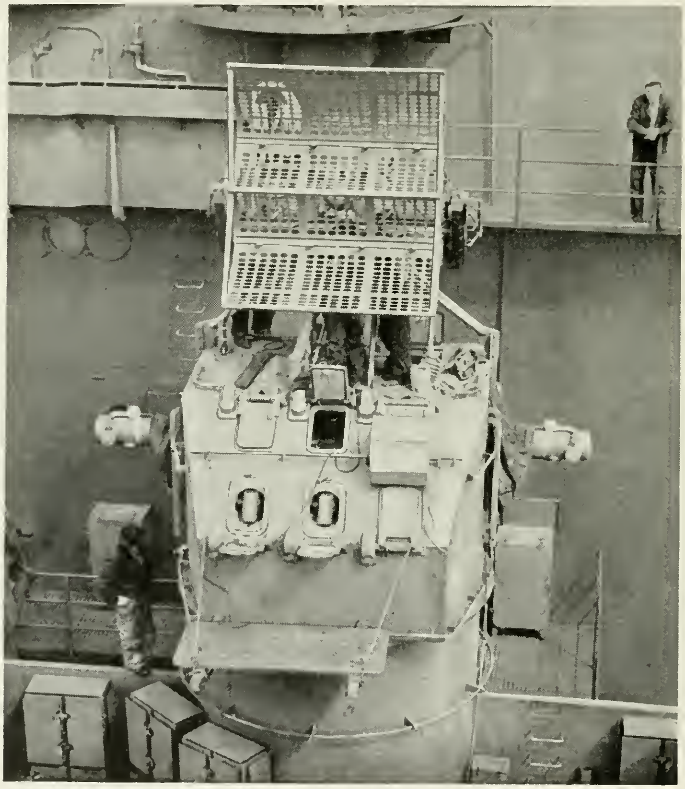
Sandy Hook, and from gas tanks in Brooklyn—some twenty miles distant. Testing and improvement continued throughout the summer, and demonstrations of the equipment's operation were given to interested Service personnel during this time.

Adequate knowledge was now available from the research to permit undertaking the development of a radar equipment to meet specified performance requirements. The Western Electric Company entered into a contract with the Navy for the Bell Laboratories' development of such an equipment for ship search and location. The equipment was given the code CXAS by the Navy. The laboratory work on the Navy project began December 31, 1939.

In order to test the relative effectiveness of different centimeter waves, the equipment was so made that tests could be made at wave lengths in the range from 60 to 40 centimeters. The equipment developed under the contract was demonstrated to the Navy at the Atlantic Highlands laboratory during December 1940.

These tests indicated the superiority of the 40-centimeter wave length,

A TYPICAL SCENE on the grounds of the Atlantic Highlands laboratory, where many tests of development models were carried out and it was adopted for the first equipments to be standardized. Soon after the conclusion of these tests the Navy authorized the design-for-production for fleet use of two equipments which later were coded Mark 3 and Mark 4.



Antenna of the pioneering Mark 4 anti-aircraft set, installed on the battleship Tennessee

The Mark 3 was for use only against surface targets, such as ships or submarines, as it could only "track targets" in the horizontal plane. The Mark 4 was for use against either surface targets or planes in flight. Both radars delivered complete fire-control data—range and angular position—with sufficient accuracy to control gun fire. These were probably the first radar equipments anywhere which delivered complete fire-control data of sufficient accuracy for use in battle.

The urgency was so great that Western Electric was authorized to proceed with manufacture with all possible speed. As soon as the design of an element of the equipment was completed, Western placed it in manufacture. In that way production began within a few months of completion of design. The Laboratories made performance tests on its first Mark 3 design model in July of 1941, and Western delivered the first production model in October. Tests were made on the first Mark 4 design model in August, and Western's first delivery was in December.

Both equipments were in production and some had been installed on Navy vessels before Pearl Harbor was attacked. Hundreds were to follow during the next year. The Navy was dependent upon them for its radar fire control in all of its engagements of the next fifteen months. The Japanese radar, at best, was feeble and too inaccurate to serve for fire control. This element of technical superiority was a most important factor in our night-time naval victories in the South Pacific in the Winter of 1942–1943.

These radars controlled the cruiser Boise's guns in October, 1942, when she blazed away at night at a vastly superior fleet in the Solomons and made the enemy pay ten to one for the damage he succeeded in doing. They were used by the cruiser San Francisco on a night in November, 1942, when a small United States force sank 27 enemy ships, almost completely destroying a large Japanese convoy bound for Guadalcanal when our hold there was precarious. The Mark 3 controlled the fire of the big guns of the battleship South Dakota in the Solomons on the dark night of November 4, 1942, when she sank a major Japanese war vessel eight miles away with two salvos.

Even in engagements in broad daylight, when optics could be used for target angles, these radars still played a vital part in furnishing accurate range which made 5-inch gunfire against aircraft, for example, deadly at long range. Thus, on October 16, 1942, when the South Dakota was attacked by planes, she shot down an even 38 out of 38 attacking.

The Radiation Laboratory, the British Science Mission, and Bell Laboratories

THERE WERE two events in the second half of 1940 which were to be of greatest importance to the Allies' development of radar. They also had a significant bearing on the part which Bell Laboratories was to play in this program.

In July, the newly formed National Defense Research Committee appointed a committee of four, under leadership of Dr. Alfred L. Loomis, to plan and to initiate its programs in centimeter-wave radar. Dr. Ralph Bown, Bell Laboratories' Radio Research Director, was one of the four. This committee, later to become Division 14 of the NDRC, was expanded, and the writer became a member.

While the work of Bell Laboratories was sponsored almost wholly by the Army and Navy and that of the Radiation Laboratory by NDRC, it was most important that the programs of these two large units be correlated to prevent duplication and to insure complete coverage of the technology. The two Bell Laboratories men who were committee members were an aid in the correlation of programs. The Army and Navy technical services, for which Bell Laboratories worked, and the Director of the Radiation Laboratory and his aides coöperated most heartily with the Bell Laboratories in the program planning necessary to make most effective use of both organizations.

In September a British technical mission, headed by Sir Henry Tizard, arrived in this country bringing the full story of the development and use of radar equipments in England. They revealed that in the preceding few months electronic research in England had made available pioneering models of a most remarkable new magnetron—a high-power microwave generator tuned by means of resonant cavities. This magnetron was capable of generating pulses of 10-kilowatt peak power at a frequency of 3000 megacycles (i.e., 10-centimeter wave length). This was more than 50 times as powerful as any other 10-centimeter-wave power source. Radar of military value at 10 centimeters was not possible with the small amount of power available from previous generators.

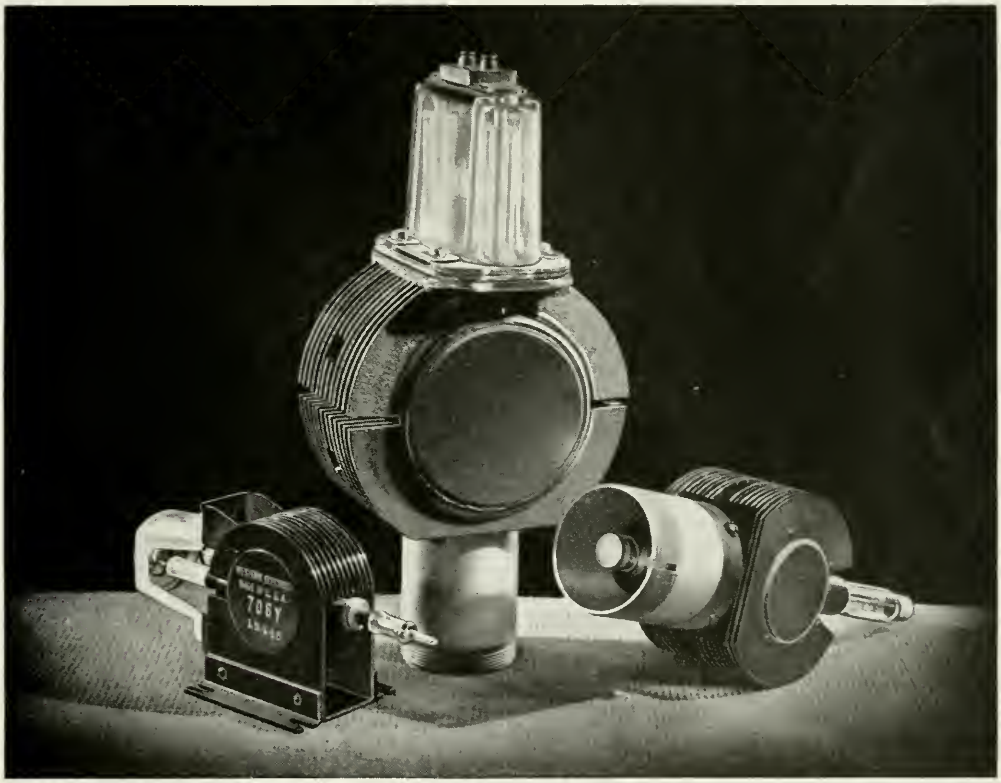
The availability of this source of high power removed the barrier, which had seemed insurmountable, to the rapid extension of radar into the centimeter-wave-length area. The British mission brought one of the early models—the E1189–12—with them. Some members of the mission and the Bell Laboratories radar research team made operational tests on this model at the Whippany laboratory on Sunday, October 7. These tests verified its reported capabilities.

The advance in magnetron technology which the British researches had brought to light was not only of great importance in the extension of radar to 10-centimeter and even shorter wave-length radio waves but it was also of immediate importance in the 40-centimeter radar developments at Bell Laboratories.

Inadequate output power of the radar transmitter was the chief limitation in obtaining reliably the required ranges against ship and plane targets with the Laboratories' CXAS radar development model. The vacuum tubes of the transmitter supplied 2 kilowatts of pulse power at 40 centimeters. This was insufficient to provide, under all service conditions, the required ranges against enemy targets. The tubes were a recent development of Bell Laboratories, and were the highest-powered 40-centimeter vacuum tube which had been developed. Their output power fell off rapidly at shorter wave lengths. Radar at 40 centimeters with these tubes would have limited application, and their radar use at still shorter wave lengths was not possible. A new source of centimeter wave power was urgently needed. The British mission brought—in pioneering form—the solution.

Immediately after the October 7 E–12 magnetron tests, electronics scientists at Bell Laboratories initiated work on a 40-centimeter resonant-cavity magnetron as well as on types for 10-centimeter and still shorter wave lengths. On December 28, 1940, tests were made on the first successful 40-centimeter model. The availability of peak pulse power of at least 100 kilowatts was indicated by these tests.

If the introduction of higher power into the Mark 3 and Mark 4 radars was to be accomplished with minimum delay, the power had to be limited to 50 kilowatts—25 times that available from the recently developed vacuum tube generators. Fifty kilowatts were adequate to insure that these equipments would have ranges well in excess of the firing range of the guns they were to control. So a magnetron for this power output was developed and designed at Bell Laboratories and put into quantity production by Western Electric in time to meet the first deliveries of the Mark 3 in October 1941. Development, design, and manufacture within a year after the historic tests on the British 10-centimeter E–12!



THREE of the many magnetrons developed by the Laboratories from the basic British design

The extension of knowledge about resonant-cavity magnetrons was perhaps the most urgent item in the rapid build-up in this country of a centimeter-wave radar research program. The Whippany tests on the British E–12 were made about a month before the Radiation Laboratory began its operation. The formation of an effective research team in electronics by the Radiation Laboratory and the equipping of the necessary highly functional electronics laboratory, even under the urgency of the preparedness program, would require many months.

Bell Laboratories carried the load of centimeter magnetron research, development, and construction of models for radar systems researches, as well as a major portion of that of other essential electronic devices, during the build-up interval of the electronics program at Radiation Laboratory. After the Radiation Laboratory's electronics program was under way, and throughout the war period, Bell Laboratories shared the research and development programs of the magnetron and other centimeter-wave electronic devices with them, with British science and industrial laboratories and, during the later war years, with a few other laboratories of the electronics industry.

TIME was of the greatest importance in the fall of 1940. A man-month of centimeter radar research at that time was to be more valuable than many times that effort even one year later. Beginning with the tests on the British E–12 magnetron, Bell Laboratories' radar research and development program in all of its phases was expanded at an unparalleled rate. Although the attack on Pearl Harbor was as yet a year off, so great was the urge for speed that regular schedules were ignored and there was even then established what later came to be the wartime rate of activity.

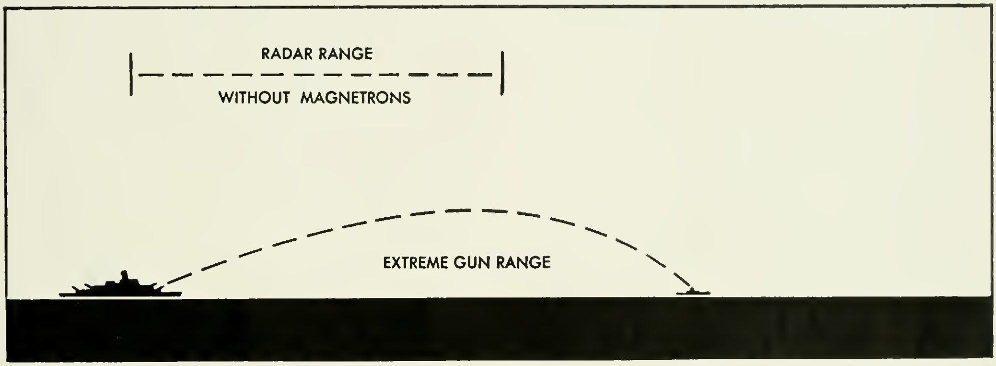
During these busy and exciting days of the late months of 1940 and early months of 1941, a spirit of comradeship and coöperation was built up between the radar scientists and engineers of Bell Laboratories, of the Radiation Laboratory, and of the British Commonwealth of Nations which was to be of great value to the Allies' radar program. Bell Laboratories' Whippany radar laboratory, Atlantic Highlands test station, Holmdel radio research laboratory, and electronics laboratory in New York were the scenes of almost continuous conferences. Groups visited Bell Laboratories to see the operation of new centimeter-radar components of great variety and to witness radar systems tests at Whippany and the Highlands.

In the little bungalow at the Highlands, work went forward night and day—with Navy officers ever present—to incorporate into the Mark 3s and Mark 4s the 50-kilowatt power and as many as possible, without delaying production, of the functional improvements which were being made almost daily by the research and development staffs. These visitors crowded and overtaxed its limited area, but they were always welcome. In later days Bell Laboratories people returned the compliment by going to their laboratories to confer and to see the many advances that were coming from their programs. The frequency and number of these visits grew throughout the war. Any day of 1944 or 1945 might have seen from five to 20 Bell Laboratories men at the Radiation Laboratory and a corresponding number from there at Bell Laboratories.

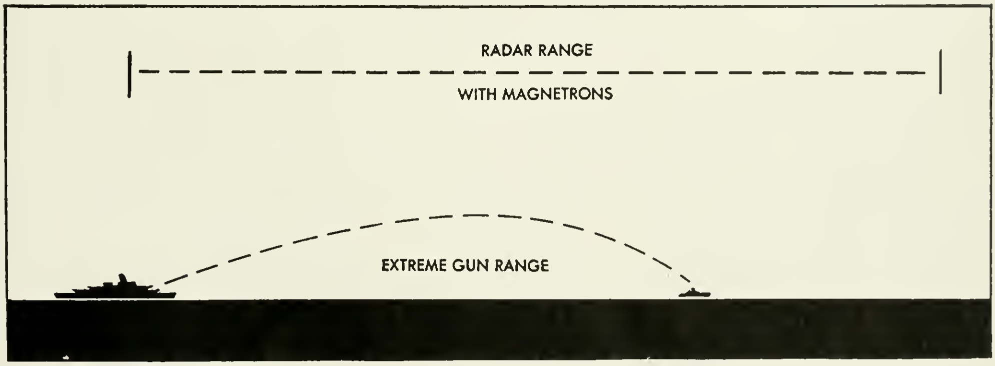
WE LOOK BACK with pleasant memories to the many visits of scientists and engineers from England, Canada, and Australia. Some of the more frequent visitors of note were the late Sir Ralph Fowler, a distinguished scientist of England; Sir Charles Darwin, Director of the British National Physical Laboratory; and Professor J. D. Cockcroft of the Cavendish Laboratory at Cambridge. We had a pleasant and most profitable visit in mid-1941 from Professor M. L. Oliphant of Birmingham University. He was a leader in British radar electronics research and had played an important part in their development of the resonant-cavity magnetron. Upon his departure for England, he said in a letter to the writer:

"During my last days in America I wish to record my deep appreciation for the complete help which I received from you during my visit to your Laboratories.

"I am certain that nowhere else in the world is such excellent work going on or such a deeply scientific attack on our mutual problems being waged."



Greatly increased power, gained by the use of the magnetron, extended radar coverage well beyond the range of the guns



The Development of Radar Systems at Bell Laboratories

The pioneering radar research of our Army and Navy laboratories in the one- and two-meter wave-length range, that of Bell Laboratories at 40 centimeters, the British contribution of the resonant-cavity magnetron, and the established communications and electronic technology supplied a broad base for our country's huge centimeter-wave radar research and development program of 1941–1945. Dr. Vannevar Bush, Director of the Office of Scientific Research and Development, in commenting on it said that advances were made in five years which in normal times might well have required three times as long.

The radio spectrum from about 40 centimeters to about one centimeter, 700 to 30,000 megacycles, was explored. Electronic and circuit components essential to the different areas of this wide wave-length band were developed, designed, and placed in manufacture from researches carried out almost concurrently. A very large number of radar systems operating in this wave-length band, progressing steadily toward shorter wave lengths as the war advanced, and dependent for their successful functioning on the new electronic and circuit components, were developed and designed for production and use. The dollar volume of production of these radar systems and components was in excess of $2,000,000,000. These facilities were of greatest importance to our victories in every sector of warfare.

Bell Laboratories became the largest developer of centimeter radar systems and their associated electronic and circuit components. More than 90 such radar systems were in development in these Laboratories. Some 60 different systems were produced by Western Electric before V–J Day and almost all of them were in active service, many in tremendous quantity.

These systems were of great variety, extending across the whole area of radar use and covering the full range of the wave-length band. Each was suited to a specific application of either land, sea, or air warfare. Our Army ground and air forces, our Navy's ships, submarines and planes, and our Marines' landing forces were all equipped with radars of Bell Laboratories development. Some of them were adopted by our Allies, and the Western Electric manufactured them in large quantity for their use.

Fire-Control Radar for the Fleet

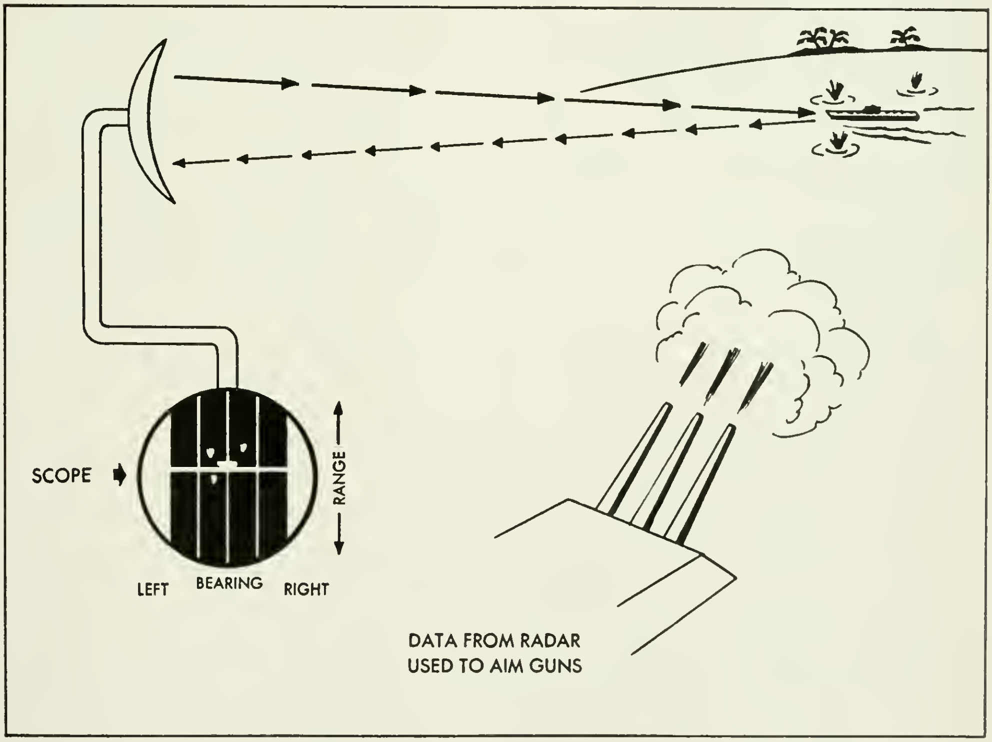
The CXAS radar which led to the large-quantity production of Mark 3s and 4s pioneered the fire-control radar developments for our Navy and Army. Throughout the war Bell Laboratories developed substantially all that our Navy used. This was one of the two largest sectors of its radar program. More than 20 systems, suited to guns of different calibers and to a wide variety of applications, were developed at the Whippany laboratory.

With a large share of the responsibility for the Navy's research and development program in radar fire control from the time of the pioneering CXAS development, Bell Laboratories' knowledge of the Navy's gun-direction problem and radar's part in it steadily grew. There developed a continuously more effective working relationship between the technical officers of the Bureau of Ordnance and the Laboratories' staff. Regularly scheduled monthly program review conferences were held at Whippany, attended by that staff, by Bureau of Ordnance officers and, frequently, by Western Electric's manufacturing engineers. There were almost daily individual contacts in Washington, at Whippany, at some Navy Yard, on a ship, or at the Hawthorne Works of the Western.

This continuing intimate relationship between user and developer made possible a very rapid advance in one of the most technically difficult sectors of radar. At the war's end every type of Navy gun had a directing radar suited to its special needs. This direction was, in general, more accurate and versatile than that afforded by optics which had been under development for decades. Advances were so rapid and intensity of effort so great that for some types of guns, such as those of the main batteries of warships and cruisers, three succeeding radars were developed, designed, manufactured, and placed in active service.

The Mark 3 was available for main-battery use at the time of the Pearl Harbor attack, the Mark 8 followed in early 1943, and it in turn was followed by the Mark 13. Each operated at a shorter wave length than the one it succeeded, and had a higher degree of accuracy, improved operational features, and added functional abilities. All of this within a five-year interval!

A radar was not made obsolete by its more modern successor, for a continuously increasing part of Bell Laboratories' expanding development effort was directed at the incorporation of the new art into the older radars. The modernization apparatus elements were sent to the fleet as "kits" and installed, according to procedures carefully worked out by the



How RADAR helps control the fire of a ship's guns: the 'scope picture accurately presents the range and bearing of the target (large spot) and of shell splashes (three small spots)

Laboratories, into equipments in service by Western Electric's field engineers and Navy personnel. There were in the fleet on V–J Day large numbers of modernized Mark 3s and 4s, and the Mark 8, which had undergone many modernizations, was still a most valuable element in radar direction of large guns.

Radar for the Submarine

JAPAN'S conquests during the first eight months of the war extended her island empire to the south and east across vast expanses of ocean. Her far-flung fronts were some 3,000 miles from Tokyo. The flow of men and materials from the homeland to the fronts had to be almost entirely by ship. This presented a most favorable situation for our use of the submarine—the Navy's most effective agent for the continuous harassing of shipping lanes and destroying of tonnage. This opportunity was recognized at an early date and a large submarine construction program was initiated.

Before radar, the submarine, of necessity, did the greater part of its hunting by day, when enemy ships could be detected by sight at much greater distances than at night by underwater acoustic detection equipment. The airplane, because of its ability to patrol vast areas, greatly increased the hazards of the submarine; and if the enemy had a sufficient number of them, he could largely reduce the effectiveness of our submarines. Our Navy's research laboratory developed an airplane detection radar operating in the meter-wave-length range for our submarines. Its value was restricted to early warning of enemy planes flying at not too low altitudes, and it was of little value as a locator of enemy ships or for detection of low flying planes.

This was the situation in early 1941 when officers of the Navy's Bureau of Ships brought to Bell Laboratories the radar problem of the submarine. Radar for detection of low flying planes, for location of enemy ships, and for torpedo direction was urgently needed. If radar could be developed to meet these operational needs and to accommodate itself to the limitations of space and to the low antenna height that would be practicable, the submarine could then hunt by night as well as by day, with greater safety and with much greater attacking power.

Studies at Bell Laboratories indicated that a centimeter-wave-length radar, suited to the submarine's needs and limitations, should meet the situation. Work was undertaken in May, 1941, and from that time until the war's end these Laboratories carried the submarine radar development responsibility for our Navy.

Western Electric produced the first centimeter-wave radar for submarines in April of 1942, and production con-

RADAR proved itself to be the vitally important attacking aid of the submarine which had been hoped for. All submarines were radar equipped: they searched out the enemy with radar, they kept themselves alerted to the dangers of enemy attack by radar, and at night they made their deadly attacks with radar-directed torpedoes. No other area of the Bell Laboratories' radar program has made so great a contribution per man hour of effort as has that for the submarine. We take special pride in it.

tinued to the war's end. The pattern of advancing technology for submarine radar parallels that of ship fire control. New and shorter wavelength radars supplanted the old, with the modernization of earlier equipments proceeding continuously.

Fleet Admiral E. J. King after the war's end reported: "Of all enemy merchant shipping sunk in the Pacific, submarines accounted for approximately 8,300,000 tons, or two-thirds. Of the naval vessels that Japan lost in the war, submarines sank one-third."

Radar for the Airplane

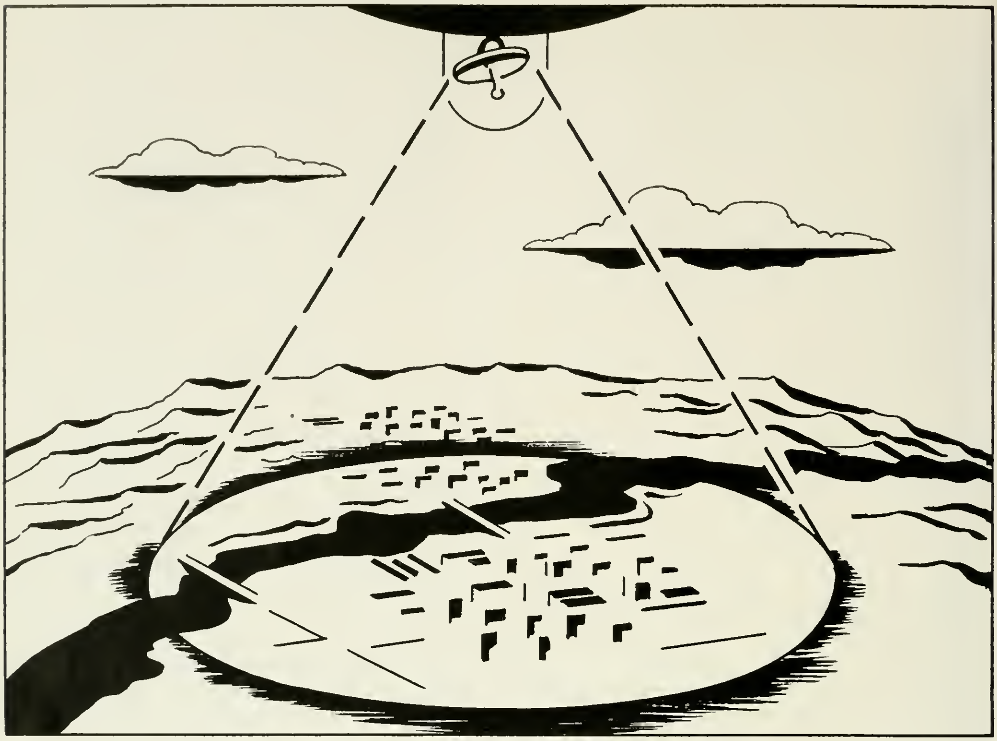
THE Radiation Laboratory and Bell Laboratories shared, in a spirit of cooperation and with continuous interchange of ideas and information, almost the entire load of research and early development in our country's airplane radar programs. The great variety of planes of our Army and Navy made necessary the development of many different functional types of radar. The tremendous number of planes led to a correspondingly large number of airborne radars. This was the largest of all sectors of radar, from research through production to military use.

Our Army and Navy planes used radar for navigation; for reconnaissance in searching out the enemy and following his movements; for interception of his planes and directing our planes' movements in their attack; for fire control of the guns of our planes; and for bombing of his ships, submarines, troops, airfields, tactical positions back of his lines, and his manufacturing plants and transportation facilities.

THE AIRPLANE has more profoundly affected military strategy than any other one weapon which has been introduced into modern warfare. It was first used in World War I, but had little effect on strategy or on victory. In World War II it played a major part in warfare on land and sea. Our might in the air determined the length of the war. Radar was one of the factors that made it possible for the airplane to play its commanding role. Without it, the airplane's value in the war would have been very much less.

Bell Laboratories developed radars for each of these functions. Similar to the pattern of progress described under "Fire Control Radar for the Fleet", improved models for each function followed one after another. With the great variety of functions, this led to a volume of effort at Bell Laboratories equal to its combined effort for ship, submarine, and ground radars.

Weight and space are at a high premium in all airplanes—more in some than in others. Even the giant B-29 could not accept an equipment for any function, no matter how important it was, until its weight and size had been "shaken down" to the lowest level possible. All airplane radar developments, therefore, had in common a highly important requirement of minimum weight and size which did not exist in radar developments for other scenes of service. The interests of minimum weight and volume are better served the shorter the wave length employed. For this reason, as well as for some that are more technical, Bell Laboratories' first airplane radars operated in the 10-centimeter wave band, and later



A RADAR ANTENNA, installed in a turret under the fuselage of a B-29 bomber, "scans" the target area

models operated at wave lengths a small fraction of this.

The Laboratories' first airplane radar development was done in coöperation with the Radiation Laboratory. It was for the night fighter plane in its interception and attack of enemy bombers. The Radiation Laboratory carried the project to the research model stage, and under Army contract Bell Laboratories carried the development forward to a production design. The latter work began in March, 1941, and Western Electric produced the first equipments in the second quarter of 1942.

These equipments were not used for their intended purpose, but were modified for ship and plane use to combat the submarine menace along the Atlantic during 1942. During the early months of the submarine warfare they were the only equipments available for some aspects of our anti-submarine action.

The Laboratories' second step in interceptor development was the SCR–720. It became available in 1943 and was standard for our Air Corps and the British RAF throughout the remainder of the war. Several thousand were produced, and were used on all fronts in Europe and in the war against Japan. Many hundreds of enemy planes and buzz bombs were destroyed by planes equipped with the 720. Perhaps of even greater importance was their protection of large tactically important areas from night-time bombing. Attack by planes employing this radar was so deadly that, after experiencing it, the enemy discontinued sending bombers over areas so protected.

The SCR–517, followed by the SCR–717, in its several modernizations, were the navigation and search airplane radars of our Army Air Corps. Bell Laboratories developed the 517 in 1941 and the 717 in 1942–1943. The 717s were made in large quantities by Western and by the Philco Company.

IN MANY respects the Laboratories' most difficult radar development for air was an all-purpose radar for the carrier-based plane. It owed much of its difficulty to rigorous requirements of weight and trouble-free operation.

The performance afforded by centimeter-wave radars was much needed by our carrier planes in 1942. They were using a radar employing a wave length of somewhat less than a meter. The radar was light enough in weight but did not have the performance capabilities of the centimeter-wave radars. The centimeter-wave radars for land-based planes were too heavy —weighing more than 350 pounds— and occupied too much space for use by the carrier plane.

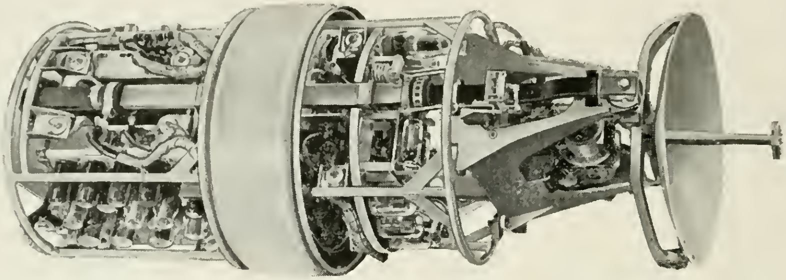
In May of 1942 Bell Laboratories undertook the development of a radar combining navigation, search, and interception functions, suitably packaged and of adequately limited volume for carrier plane installation. It was to weigh about half as much as radars employed in land-based planes, to perform about as well as those weighing twice as much, and to meet most rigorous requirements covering maintenance-free operation.

The development met most of those objectives by mid-1943, and production was started by Western Electric before the end of that year. During 1944 and 1945 Western and the Westinghouse Company produced many thousands of this equipment. It was produced probably in larger quantity than any other centimeter-wave radar equipment of the war.

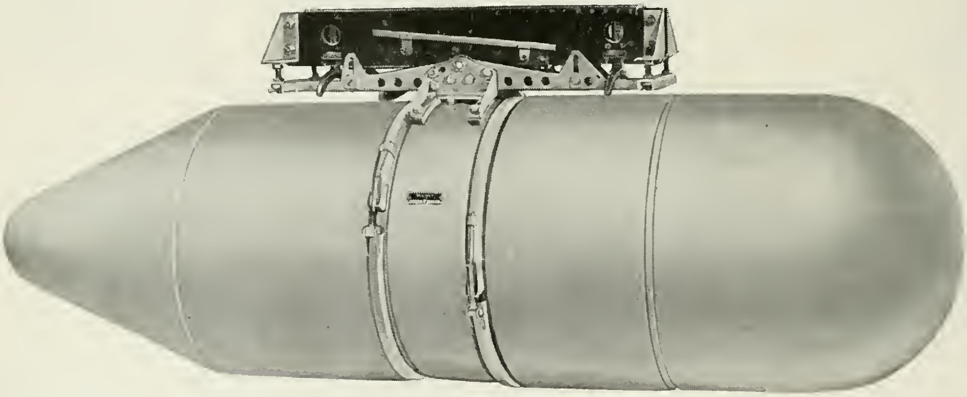
In reporting on the equipment one of our Navy's carrier plane pilots said: "This radar works well with the many jobs we are called on to do. These include searching out Japanese targets, intercepting his planes, navigating in strange territory, and homing to our carrier. It is also most helpful to the pilot in his flying in, over, and around tropical rain squalls and pointing out targets through overcast."

RADAR bombing equipment evolved from the search radars. As shorter wave lengths—still shorter than 10 centimeters—became available, sufficient resolution of objects was possible to permit the recognition and bombing of many sorts of specific targets, such as harbor and riverside installations, bridges, and even certain industrial plants. Bell Laboratories researches in radar bombing, which began in 1941 under authorization by the Army Air Corps, were gradually expanded, and led to the development and design of several radar bombing equipments suited to different applications.

From these designs Western Electric produced the largest volume of radars for bombing of any supplier. One of these equipments became the standard radar bombsight of the Army and Navy for bombing ships at sea from relatively low altitudes. Reports from the Pacific Theater indicated that a bomber squadron's efficiency in ship sinking increased severalfold after the introduction of this equipment.



Compactly built into a bomb-shaped casing, this carrier-plane set reached the highest production figure of any centimeter-wave radar

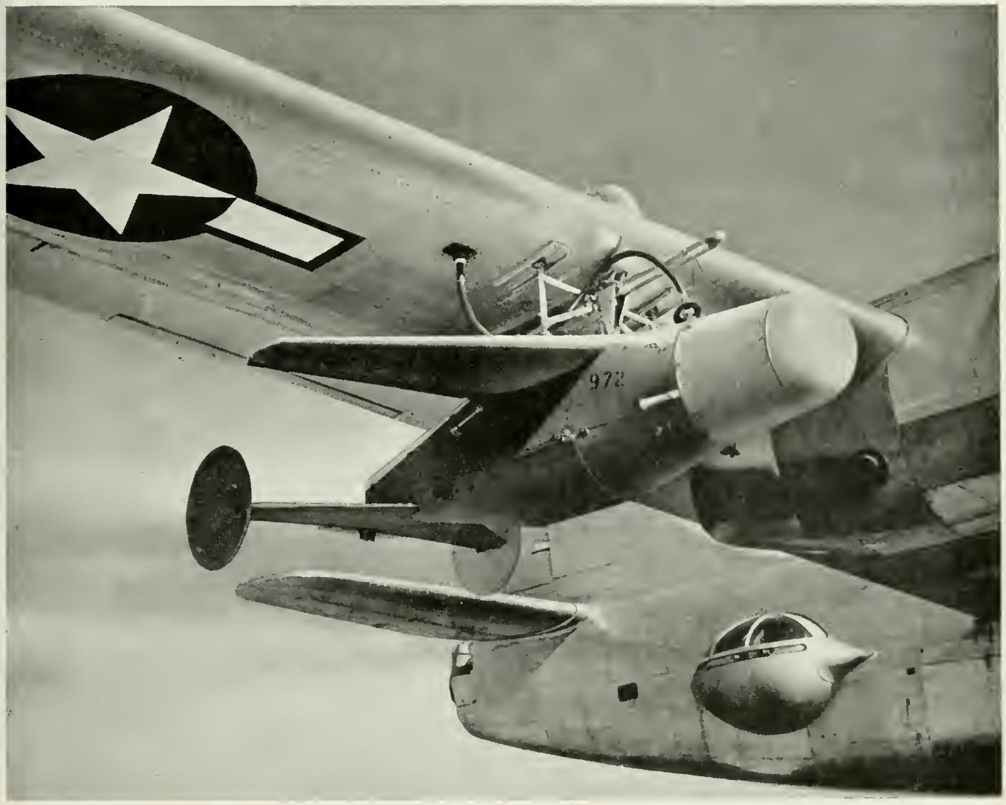


Two of the equipments were standard for B-29s in their bombings of the Japanese home islands. Most of the damage done by the B-29 raids was by bombs directed by these radar equipments.

The Laboratories' radar bombing researches had as their ultimate objective the bombing from high altitude through the overcast with an accuracy against individual targets equal to that of optically directed bombing. This was accomplished during the final months of the B-29s over Japan. Radar bombing scores against individual targets were equal to those of optical bombing under good visibility. From some viewpoints this was a greater technical accomplishment than that of our accurate fire control radars. The radar bombing equipment not only had the same objectives of high precision as did the fire-control radars; it also had to meet the severe weight and size limitations essential for airplane use—a most difficult task which required almost four years of intensive research and development on the system and its component apparatus.

The Radiation Laboratory and Bell Laboratories continuously interchanged information and ideas on radar bombing. There was also a sharing of responsibility and work load on some of the projects.

Bell Laboratories coöperated with the NDRC in the development for the Navy of a radar-guided winged bomb, called the Bat. Under a Navy Bureau of Ordnance contract the Laboratories developed the radar head which supplied the directional or "homing to the target" information. The NDRC developed the glider and automatic controls for its steering from radar-received data. It was standardized for use and large quantities were manufactured. The Western Electric Company produced the radar heads according to Laboratories' designs. The Bat sank many tons of Japanese naval and merchant shipping during the final months of


THE "BAT", a radar-guided winged bomb, slung under the wing of a Navy bomber

the war. It was the first missile of its type ever successfully used in combat.

Radar for Ground Use

RADARS operated from the ground have found broad application by the Army Ground Forces, the Marines, and the Army Air Forces in the protection of airfields and other fixed installations from enemy airplane attack. They have also had extensive use in the protection of newly won beachheads and permanent shore installations from attack by ships and planes. Ground radars have been of two general classes: search and fire control.

During the 1930s the Signal Corps carried out a pioneering program on radar at their Fort Monmouth, N. J., laboratories under the direction of Colonel (now Maj. Gen., retired) Roger B. Colton, and completed the development of two ground radars before the war began. Like the Naval Research Laboratory, their program was in the meter wave-length range. They directed their attention to the development of equipments for search and early warning of enemy planes.

Bell Laboratories was brought into contact with the Fort Monmouth developments in 1938, and from that time there was a continuing interchange of information between the two groups. In mid-1939, when the Laboratories moved its first centimeter-wave-radar equipment from the Whippany laboratory to the Atlantic Highlands laboratory, Colonel Colton and his aides were among the first visitors there, and they continued to follow the developments at the Highlands laboratory.

In the spring of 1940, the Signal Corps requested the Western Electric Company and Bell Laboratories to undertake the design-for-production and the manufacture of one of the search and early-warning radars which the Fort Monmouth laboratories had developed. The Signal Corps wanted this equipment in quantity production at the earliest possible time.

In order to proceed with the design and preparation of manufacturing information at the greatest possible speed, the Bell Laboratories' project group was provided with work space at Fort Hancock, N. J., in close association with the Signal Corps group which was developing this radar. As rapidly as design information was completed on an element of equipment, Western Electric proceeded with its manufacture. The first equipment, coded SCR–268, was delivered by the Western Electric in February, 1941, less than eight months from the beginning of Bell Laboratories' work on the project.

WESTERN ELECTRIC continued the manufacture of this equipment until 1944. More than 1,000 equipments were produced, and they saw service in almost all theaters of the war. Bell Laboratories made two major modernization redesigns of the equipment and there was a continuous flow of detailed changes that required the engineering of modernization kits for application to equipments already in service.

The SCR–268 equipment was mounted in a truck and trailer. Other early warning equipments developed by the Signal Corps laboratories were still larger and had to be permanently installed where they were to be used. Combat experience soon pointed out the need for a search equipment which was sufficiently light in weight and packaged into small enough units so that it could be flown into newly established airfields. In order that protection from enemy air attack on these fields could be quickly established, the equipment had to be capable of being installed and operated within minutes after it was flown in. The requirement for light weight and unit packaging could only be met by employing a much shorter wave length than that of the SCR–268. Technical requirements also indicated the use of a shorter wave length.

To MEET these requirements, Bell Laboratories developed for our Army Air Forces and Marines an air-transportable centimeter-wave radar for search and early warning of enemy planes. This equipment was coded the AN/TPS, and it was manufactured in large quantities by Western Electric. It was extensively used, and was of special importance in defending the many conquered Pacific Islands from enemy raiders. Several were used on Iwo Jima and Okinawa.

Bell Laboratories developed three fire-control radar equipments for ground use: two for use by the Army Ground Forces and one for use by the Marines.

The SCR–296 fire-control radar was developed for the protection of shore installations from attack by ships. It was permanently installed, with its antenna mounted on top of a tower of height varying up to 100 feet, depending upon the topography of the location. The antenna had to be sufficiently high so that its radar beam could reach enemy ships several tens of miles beyond the shore, in order that shore defenses could be alerted in time and "tracking" for fire control be under way well beyond the range of the guns controlled. This radar employed the wave length and many of the techniques of the original Mark 3 for ship fire-control use. A few hundred of them were manufactured by Western Electric, and were installed for protection of shore installations in many of the theaters of war. In common with other radars, there was continuous modernization of the equipment to keep its performance abreast of the advancing art.

An anti-aircraft radar fire-control system, truck and trailer mounted, which incorporated a search radio beam as well as one for gun-pointing, was developed for control of the fire of the anti-aircraft batteries of the ground forces. It was coded SCR–545. The search beam was in the one- to two-meter wave length range and provided a beam of such breadth that it was easy to locate planes at a distance of many miles. As they approached gun-fire range, a particular plane was selected for "tracking" and the centimeter-wave "gun-pointing" beam followed this plane and continuously supplied information for direction of the gun fire. This equipment was used in the protection of the Anzio Beachhead in Italy and in the Pacific Theater.

A considerably lighter truck-mounted fire-control radar, the Mark 16, was developed for the Marines. This equipment was suited to their needs in the Pacific Islands warfare. It was taken ashore soon after a beachhead was established, to protect it from attack by planes or ships. A few hundred of them were used throughout the Pacific Theater in the protection of newly won islands.

Components and Circuit Elements for Radar

In the development of new communications systems there needs to be the most intimate interplay between the advancing technology of the system, its components, and its circuit elements. By experience gained in the development for the Bell System of new radio and wire transmission systems with their intimately related switching systems, Bell Laboratories has evolved a most effective pattern of relationships and team play between new systems philosophers, developers, and engineers and the scientists who carry out researches basic to the new components and circuit elements. The knowledge of how to integrate into an efficiently working team men having the great variety of technical skills essential to the simultaneous creation of new systems and their new components and circuit elements was necessary for the Laboratories' development of almost one hundred new centimeter-wave radar systems within a period of some five years.

Radar, *like all communication systems, is an ordered aggregate of electronic and electro-mechanical components and circuit elements interconnected by suitable electrical conductors. Each component and circuit element is designed to meet its functional part of the system's operation. The interconnection is engineered so that the integration of the operations of the individual elements produces the desired system performance.*

Beginning with Bell Laboratories' first radar studies in 1938, those expert in the research and development that lead to new components and circuit elements were made a part of the radar systems research and development team. New electronic devices, electrical networks, transformers, coils, potentiometers, resistances, relays, condensers, thermistors, crystal converters, and varistors were made available first as research models for systems study and later as development models preliminary to the final design for service. In each succeeding year the number of new components standardized for production was greater than in the previous year. In 1944 the design of more than 1,500 components essential to radar was completed, in comparison with less than 1,000 in 1943.

Not only were the radar systems of Bell Laboratories development dependent upon these new components but also those developed by others would not have been possible without them. The demand for them was so great that even with its large expansion Western Electric could not produce all that were required. The Laboratories' new components were always placed in manufacture by Western, but many were later shifted in whole or in part to other manufacturers in order that Western might make available capacity for still newer components which had to be produced with greatest speed in order to meet new radar systems needs.

New electronic devices—magnetrons, beating oscillators, pulse power tubes, intermediate frequency amplifier tubes, gas switching tubes and many other electronic elements—

were the keystones to the rapid progress of the centimeter radar art. Bell Laboratories was a major contributor of new electronic devices of almost all varieties which determined the speed of radar's advance. During the 1940–1945 period, the Laboratories designed and standardized some 175 different electronic devices essential to radar. Western supplied them in large quantity. The dollar volume of their deliveries exceeded $100,000,000; almost twice the dollar volume of all electronic devices manufactured for Bell System use from 1915 to 1940.

Large quantities of Bell Laboratories developments were supplied by many other manufacturers. The requirements for some types were so large that it was necessary for the Services to obtain production from several manufacturers. In the case of an intermediate-frequency amplifier tube—the 6AK5—there were five suppliers in addition to Western.

Bell Laboratories electronics developments covered the wave band from 40 centimeters to 1 centimeter and every radar electronic function except display. The cathode-ray tubes used in the video system to display the radar pictures were developed by others. While the Laboratories' electronics programs were carried out under Army and Navy contracts, they were closely integrated with those of the NDRC. In authorizing a program in one of the new wave length sectors, the Bureau of Ships wrote in part: "The Bureau expects the Western and Bell Laboratories to assume the same responsibilities in the development and manufacture of the electronic devices for the new —— band as have been carried so well in the other bands."

The 6AK5, one of the most important vacuum tubes developed for radar use

Bell Laboratories' contribution to the development of the many other types of components, circuit elements, and coaxial cable and wave guide transmission interconnectors was as broad in scope and as fundamental to all centimeter-wave radars as were its electronic developments.

Radar Systems—Designed for Service

The radar systems operating in the wave band from 40 centimeters to 1 centimeter made the first general use of this vast range of the radio spectrum. For several years before 1940, research in Bell Laboratories was probing this wave band to determine its value to communication. The volume of this research was in balance with the many other sectors of the research program.

With the advent of radar and war, Bell Laboratories expanded this research effort several fold, and the scientists at the Radiation Laboratory also made large contributions in this area. Building upon the knowledge so rapidly accumulating from this greatly expanded research effort, the Bell staff of systems and components developers produced in rapid succession development models of radar systems having greater range of vision and higher resolving power and capable of more accurate measurement of an object's location. In the development of these radars, the Laboratories' research and development teams were operating in familiar territory, for their pattern of effort was the same—except for the pressure of time—as that normally followed in obtaining new knowledge through research and then applying it in a closely integrated program to the development of a new communication system and its components.

Following the development model, though getting under way before its completion, comes design for service. This is an area of communications technology that Bell Laboratories has developed to a high state of proficiency. Its responsibility for the design of the communications facilities for Bell System use, with the philosophy of designing facilities that provide the best communications service at the lowest possible cost, has built a "service for the user" attitude into the fiber of the organization. In order to arrive at the best designs for service, there have evolved at the Laboratories through the years highly effective teams of electrical and mechanical designers and of chemical, materials, and metallurgical engineers closely integrated with scientists, systems engineers, and components development engineers. These teams are equipped with specialized facilities for the evolution of service designs and for appraising their adequacy.

MORE THAN HALF of the Bell Laboratories design organization—with greatly expanded aid in drafting, laboratory experimenting, testing, and model construction—were engaged in designing radar systems and components. During the early years, design for service was the most difficult sector of radar effort. This was due principally to the time schedules imposed by war and to an inadequate knowledge of user or service requirements.

The need for equipments was so urgent that a greatly compressed time scale was a necessity throughout the war, but was at its maximum during the early years. The best possible, within the time, had to be done; and great ingenuity was shown in the overlapping of procedures that normally best follow one after another. Not only were procedures within the Laboratories telescoped, but also the final design effort and Western's engineering and planning for manufacture were carried on practically simultaneously. Had it not been for the many years of coöperative effort of these groups under normal conditions, time compression so effective would not have been possible.

A step that proved of great value in time saving was the placement of large groups of Bell Laboratories designers and their draftsmen at each of Western's manufacturing centers. Their work was so highly secret that the large areas of space they occupied were enclosed in wire screen. These became known as the "Labs' Cages," and they were the focal points where Army and Navy officers and Laboratories and Western engineers settled a steady stream of detailed questions on materials, processing, design, and testing. The "Cages" were kept in hourly contact with the development teams at the Laboratories through telephone and teletypewriter. Almost every day saw engineers from the "Cages" at the Laboratories and those from the Laboratories at the "Cages".

It soon became evident that knowledge of user requirements was inadequate. Radar was a new military instrument; it had never before been used in warfare. It was to be used by every branch of our Services. The theaters of battle were all over the world. In consequence, environmental problems were world-wide.

The dry and dusty heat of the African desert, the humid heat of the tropical islands of the Pacific, the cold and ice of the Artic, and the low pressures and temperatures of planes flying at 20,000 feet were extremes of climatic conditions in which radar must operate trouble free. The design-for-service of a radar performing similar tasks was quite different depending on whether it was for use in a surface vessel, a submarine, on land, or in a plane. Differences in available space, shock and vibration conditions, details of operating procedures, and many other factors combined to make the radar for each task a special job.

Neither Bell Laboratories engineers nor the technical officers of the different Services knew, at the war's beginning, the answers to many of the questions on design-for-service posed by this variety of climatic environments and of locale of installations. However, the Laboratories had specialists in large number with the knowledge of how to determine requirements for trouble-free, convenient, and effective operation and maintenance and how to apply them in design. These specialists, in closest coöperation with the different Services, proceeded with greatest energy to obtain knowledge so that equipments could be designed to meet any of the service and environment conditions of world-wide war.

They went to the Tropics, to the Arctic, in planes to 20,000 feet altitude, to the sea in ships of many classes, and under its surface in submarines. They observed service and environment conditions of every kind. The knowledge gained through such visits, from laboratory investigations that followed, and from consultations with the different Services, was translated into design requirements. Facilities were developed or procured for making tests in the laboratory under conditions closely equivalent to those in service. At the war's close, the radar test laboratory at Whippany was one of the most completely equipped in the country for testing of ground, sea, or airborne radars.

With steadily increasing knowledge of the users' needs, and with facilities for design and service test under constant improvement, the radars of Bell Laboratories' development each year gave more nearly trouble-free service and required less maintenance than those of previous years. In the final months of the war, the bombing radars in the B-29s were giving better than 98 percent trouble-free service on their missions over Japan.

Rear Admiral G. F. Hussey, Jr., Chief of the Bureau of Ordnance of the Navy, in a letter of comment upon the design of one of the last ship fire-control radars, wrote in part:

"The Bureau considers that this equipment represents a marked advance in radar design, particularly from the standpoint of reliability and ease of maintenance. It indicates clearly the benefits to be derived from experience, sound design engineering, and excellent manufacturing techniques. While fleet experience with this equipment is still limited, reports indicate that it is considered the best radar equipment yet installed on shipboard."

Special Services Essential to the Radar Systems Programs

In assuming the responsibility for so large a portion of centimeter radar technology—the underlying research and the development and design of radar systems and components—it was necessary for the Laboratories to carry out several special assignments closely related to its radar systems programs and essential to the Army's and Navy's most efficient use of the systems.

These assignments included the development of radar test sets, the preproduction of radar systems and components, the preparation of technical manuals and instruction books on radar systems, and conducting a radar school for commissioned and enlisted personnel and civilian experts of the Army and Navy.

Radar Test-Set Development

A radar system is a most complex equipment. Typical radars have from 50 to 250 vacuum tubes, associated with many times that number of condensers, resistances, transformers, coils, electrical networks, and various electro-mechanical components. Notwithstanding most careful design, it is easy for radar performance to become impaired under operating conditions.

The greater the range of coverage and the more accurate the data of a radar, the more valuable its information is likely to be. The range of coverage may fall to a fraction of the normal, or the accuracy of measurement may decrease by a large amount, with nothing in the radar's performance to indicate it. There must be test facilities at the battle fronts which make possible checking and adjusting the radar to insure that the normal range of coverage and highest possible accuracy are always realized.

Previously existing electrical test equipments were not suited to the solution of most of centimeter radars' test problems. Their use of new wave lengths and of a large variety of new circuit techniques made necessary the development of many completely new test sets.

Radar test-set technology had to be kept in step with the rapidly moving radar systems developments. This could only be done by a most intimate association of test-set development with systems development.

The pattern of the test-set work became substantially the same as that for the systems themselves. The Radiation Laboratory and Bell Laboratories shared the major portion of the responsibility. The two organizations worked in close coördination with each other and with the Services to prevent duplication and to insure complete coverage.

From 1940 to 1945 the Laboratories developed and designed for service over 200 different radar test sets. They were of great variety: special oscilloscopes, signal generators and power meters for all the different wave length bands, frequency meters, range calibrators, phantom targets and echo boxes are typical test set names. Western Electric produced more than 75,000 sets of Laboratories' design. The rate of production was 5,000 per month at the war's end. The Army and Navy used test sets in increasing number and with ever-improving effectiveness in maintaining radar systems at the battle fronts at highest level of performance.

PRE-PRODUCTION OF RADAR SYSTEMS AND COMPONENTS

AFTER the design model of a radar system was approved by the Service using it, an interval of four to eight months might well elapse before quantity production could begin. This interval was used in the procurement of materials, the design and construction of special tools and equipment for production and testing, and the preparation of manufacturing space. This interval was of great concern to the Services; it was not possible for them to begin their training programs or to make limited tactical studies at the front until the quantity production line had started moving. Four to eight months of most valuable time were almost completely lost.

To meet this situation, Bell Laboratories, at the urgent request of the Services, began the construction in special job shops of a limited number —from 5 to 30—of its newly developed radar systems during 1943. This production could be under way as design was nearing completion; and since it was intimately associated with the development teams, the work could be carried out without operator training and with limited special tooling, equipment, and test facilities. It was thus possible for deliveries in these limited numbers to begin almost immediately after the approval of the design model and to be completed before quantity production started.

While this was a very expensive way to produce radar equipments, the service proved to be of such great value in its saving of time that it grew rapidly. It became necessary to limit pre-production by a critical examination of each request, in order that its volume might not overtax the Laboratories' capacity and slow down its development programs.

The 1943 dollar volume of radar systems pre-production was $3,000,000, and in 1944 it increased more than three-fold. It continued at an average level somewhat in excess of $1,000,000 per month until the war's end. This service was unique; its nearest equivalent was a job shop at the Radiation Laboratory for construction of development models in small quantity for similar purposes.

Bell Laboratories also made, on a

To BRIDGE the gap between design and quantity production, the Laboratories set up a pre-production shop—a corner of which is shown here—where limited numbers of new equipments were completed

job shop basis, a large volume of its components of recent development in order that the Service laboratories, the Radiation Laboratory, and industrial laboratories could obtain new components for evaluation and use in the development of radars in advance of the time Western could start quantity production. This service was of great value in accelerating evaluation and standardization of new components by the Services and the development of radar systems by others.

TECHNICAL MANUALS AND INSTRUCTION BOOKS

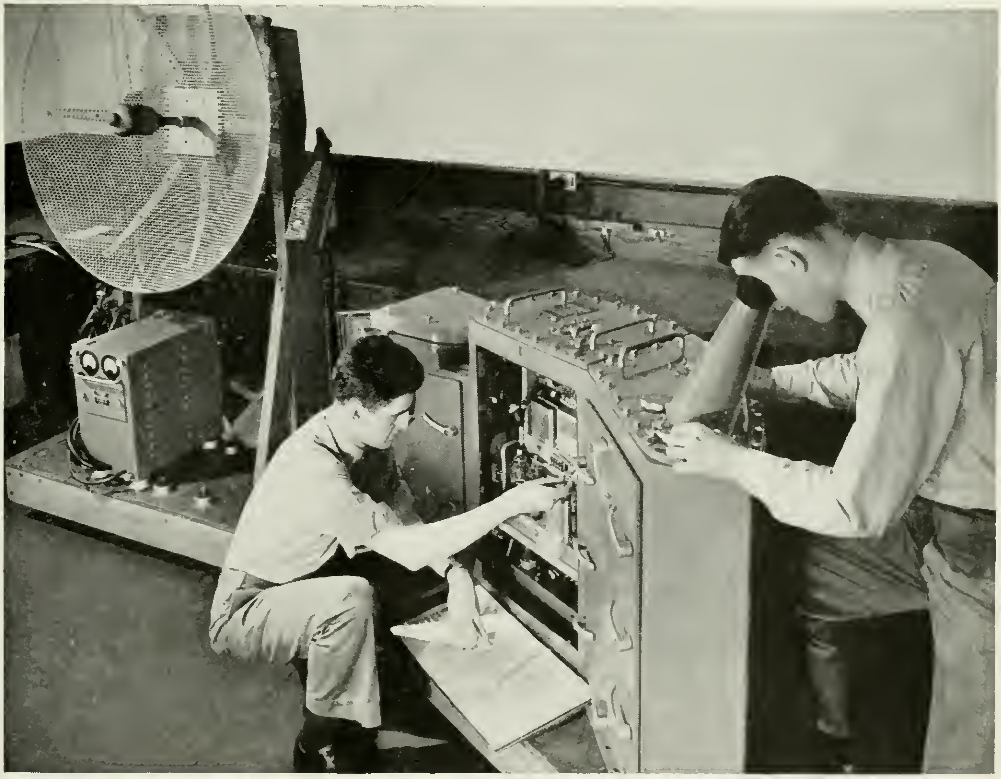
RADARS were sent to far distant war fronts in Europe and Asia. It was most important that the officers and men of the Services at the fronts be provided with complete technical manuals and instruction books for each radar system. As these systems were modernized, new editions of the books and manuals describing the changes had to be at the fronts as soon as the "modernization kits." Communications systems, sonars, gun directors, and many other instruments of war which Bell Laboratories developed had a similar problem of technical manuals and instruction books.

To care for the rapidly expanding load of book writing, the Laboratories established an editorial department which worked in intimate relationship with the development groups responsible for each of the different military equipments or systems. In 1944 alone, 366 separate instruction books and technical manuals were prepared for the Laboratories' developments of that year. More than 200 of them were concerned with radar systems. There were nearly 60,000 pages of text for all books and manuals, and more than 17,000 illustrations. In that year the Laboratories became the country's largest publisher of new books.

School for War Training

In a manner similar to its preparation of manuals and books, the Laboratories segregated all of its instruction activities for the Services in a "School for War Training." The staff of the school was selected principally from members of the Laboratories' technical staff and engineers lent to the Laboratories by Associated Companies of the Bell System, and during the maximum enrollment numbered about 75. The school occupied a number of lecture, laboratory, and conference rooms. The courses covered lectures, laboratory work, conference quizzes, and examinations. Many were at the college level, and students were required to have had previous training in science and mathematics.

During its more than three years of operation, the school conducted about 125 different courses, which were at-



Future Navy radar officers learn about fire control radar at the Laboratories' School for War Training tended by some 4,200 students assigned to them by the Armed Forces. More than 80 percent of this number were from the Army and the rest from the Navy. More than one-half of the School's courses were concerned with radar. The policy of the Services varied as to the number of their personnel who were given this basic training. All of the Navy officers who were in training for fire-control assignment attended the school, and the Navy required one graduate aboard each major combat vessel. Almost every new radar system brought a group for special training in its theory and practice.

Coöperation with Others

THE ALLIED NATIONS matched the Axis Powers in the application of science to warfare before the mid-point of the war had been reached, and surpassed them by its close. As the Axis had devoted a large and increasing portion of its science and technological strength to the development of new instrumentalities for war during the preceding decade, and the Allies' similar effort had been extremely small in comparison, this was indeed a remarkable accomplishment.

Many factors contributed. Two of the most important were: The Allies' scientific and technological strength was greater than that of their enemies; and the coördination of effort and the coöperation of scientists, technologists, and the military within each allied country and between them were at a high level of effectiveness while, as we learned after the war's end, the corresponding coördination and coöperation of the Axis Powers were at a low level.

Radar development was a model of effective coördination and coöperation within each allied country and between them. Bell Laboratories was one of the foci of coöperative effort. It is with pride and satisfaction that we look back on our participation in the coöperative activities from mid-1940 to the war's end. Information from Bell Laboratories radar programs was available to all who were cleared by the Army or Navy. The laboratory door was always open for the entrance of authorized visitors, and through it the Laboratories' technical memoranda went to all groups who had official clearance.

In 1944 there were approximately 20,000 authorized visitors to Bell Laboratories. Some 60 percent were interested in radar technology. Nine thousand were from American industries, 8,500 from our Services, 1,700 from the NDRC, and 500 from our Allies.

While no accurate count has been kept of radar memoranda sent to the NDRC, the Services, and American industry, a count of those supplied the OSRD for transmission to our Allies has been kept. From mid-1942 until the end of 1944, about 500 such reports were sent. This is approximately one-third of the total concerned with centimeter-wave radar which OSRD transmitted. One-third was supplied by the Radiation Laboratory, and one-third by all others. Prior to mid-1942, Bell Laboratories, after Service clearance, supplied the British Scientific Office in Washington with some 300 memoranda for transmission to the British Commonwealth organizations.

In like manner, Bell Laboratories obtained information of aid to its program from the laboratories of our Allies, Government, and American industry. Because of its volume, mention has frequently been made of the coöperation between these Laboratories and the Radiation Laboratory.

Bell System's Contribution to Victory

In a companion article, the story of Western Electric's enormous production of radar for our Army and Navy is told. Western's and Bell Laboratories' contributions are an integrated whole, one complementing the other. There was no more of a discontinuity in the smooth and ordered flow of the radar program from research to completed equipment between Laboratories and Western than between parts of the program within each organization.

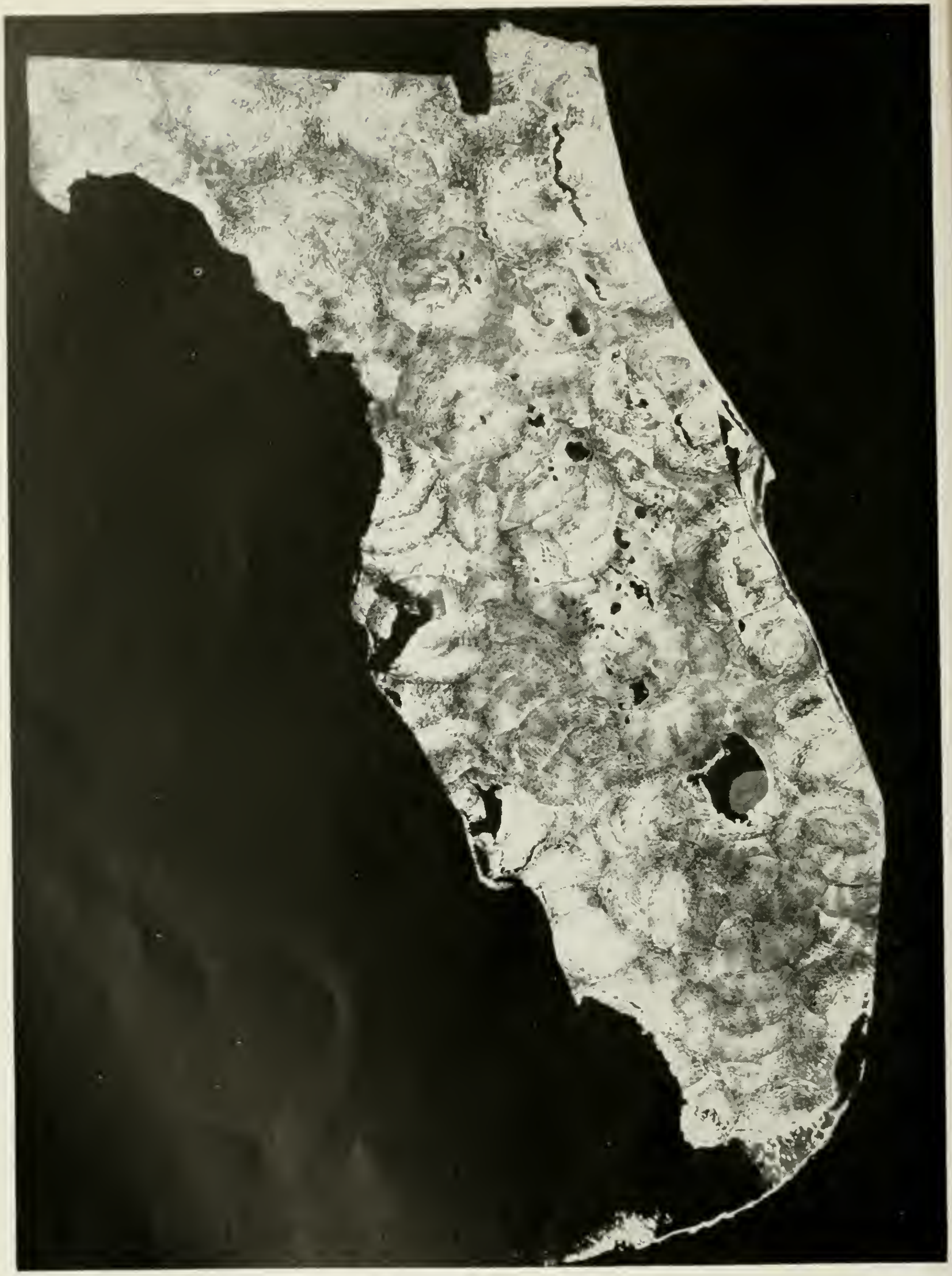
This teamwork is an old story; for the two organizations have, over a long period, provided new communication facilities for the Bell System through a technical program beginning with research at the forefront of science and proceeding through ordered steps of development, design, manufacture, and installation in the Bell System's nation-wide plant. Over the years the teamwork essential to the successful carrying out of this large technical endeavor has become increasingly effective.

These organizations, functioning as a unit, turned their attention to radar in 1938 and began an expansion of effort in 1940 which continued until the war's end. Almost 50 percent of their expanded capacity was used in a complete radar service for our Army and Navy. This service was similar in so many ways to that which they normally rendered the Bell System that it was possible to expand rapidly every phase of it and to assume the responsibility from development through production for almost half of our Services' new centimeter-radar systems. The volume of equipments produced, the extent of their use, and the quality of the service they rendered on the many battlefronts of all theaters of the war are measures of the Bell System's radar contribution to victory.

Who's Who & What's What

(*Continued from page 219*)

Department. He entered the business in 1913 as chief clerk in the Commercial Department at Erie, and subsequently served as manager at Erie and Warren. In 1919 he was transferred to what was then called the Publicity Department in Philadelphia, and served successively as advertising supervisor and general information manager prior to his present appointment, which dates from 1941.



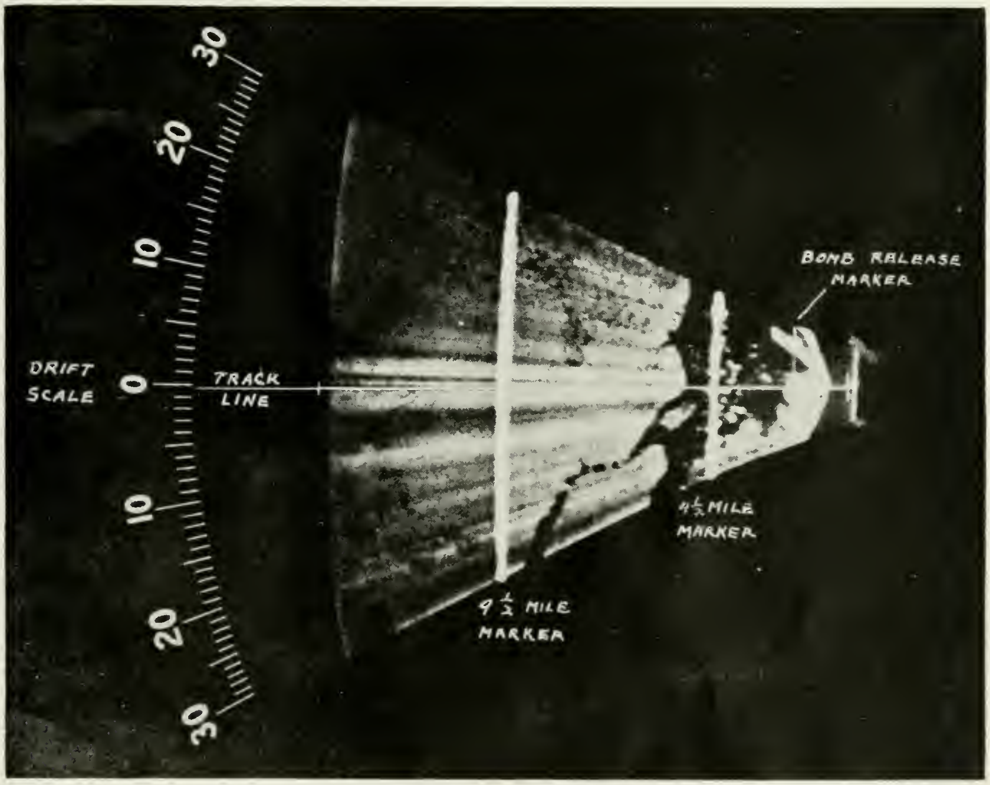
One of the most remarkable pictures ever made, this radar mosaic shows the State of Florida in scale of 1:3,999,999. It was made through overcast with Western Electric radar by Army fliers attached to Boca Raton Army Airfield, Florida

Radar: A Story in Pictures

SIX YEARS AGO, responsible persons would have dismissed as fantastic the idea of photographing an entire state through a blanket of clouds. Yet today, the production of mosaics like that on the opposite page has become routine for military men. Perhaps never before in the history of science has a development such as radar progressed with such amazing speed.

In six short war-torn years radar mushroomed into a \$2,700,000,000 development and production enterprise. The many stories of its achievements—helping to save Britain during the fateful German air offensive, hunting Nazi wolf-packs in the Atlantic, curtailing the V-1 menace, sinking Japanese shipping both merchant and naval—all have implicit in them not only the factors of quality and quantity production but an intangible element more difficult to sample and appraise. It is that element in human behavior which rises in behalf of a righteous cause and transforms an almost fleeting idea into magnificent reality. No other explanation accounts fully for the radar achievement.

In the decade from 1930 to 1940, aircraft were beginning to travel with



WHEN THE TARGET comes within range, airmen switch their "p.p.i." scopes to "sector scan" (above) and bomb with the aid of "electronic cross-hairs"

An aerial reconnaissance picture of the Japanese industrial city of Toyama, which turned out large quantities of ball bearings, machine tools, textiles, and alloy steels

speeds only half the velocity of sound itself, so that the warning interval which could be achieved by listening was quite inadequate. A high-flying airplane is difficult enough to detect visually even under the best conditions; and to find its range by optical means, the only pre-radar method available, always proved troublesome and often impossible. The accuracy of anti-aircraft fire suffered accordingly, and it appeared that a successful defense against hostile aircraft by fighters would require constant patrolling plus a generous measure of plain luck.

Radar made possible the timely alerting of all defenses. Fighters could be "scrambled," and then coached to an advantageous contact with the incoming raid. Anti-aircraft guns could be pointed automatically at unseen targets with greater precision than formerly characterized the sighting of visual fire.

Moreover, radar could aid greatly in increasing the impact of offensive warfare. For example, a former axiom of sea warfare had it that naval battles were decided by the factor of who happened to be "up-sun" from the enemy. With radar, our ships slugged through whole engagements in which the enemy was de-

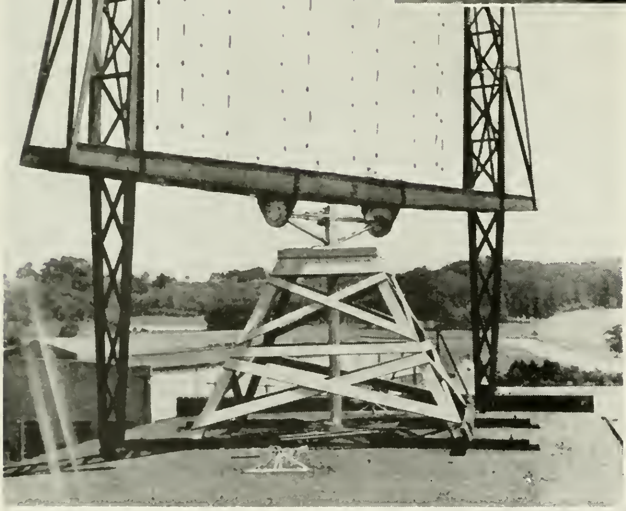
TOYAMA 90 percent aflame as the Superfortresses turn homeward on the night of August 2, 1945: the result of pinpoint bombing by radar

tected, ranged on, and sunk without a single man having seen him visually.

Before the days of radar, either "base weather" or "target weather" could bog down strategic bombing forces. By the war's end, airmen returning to fog-locked bases were talked down by means of two-way radio telephone from accurate data supplied by land-based radars. Not only could radar-equipped planes navigate unerringly to the target area; they could line up on the target and bomb blind.

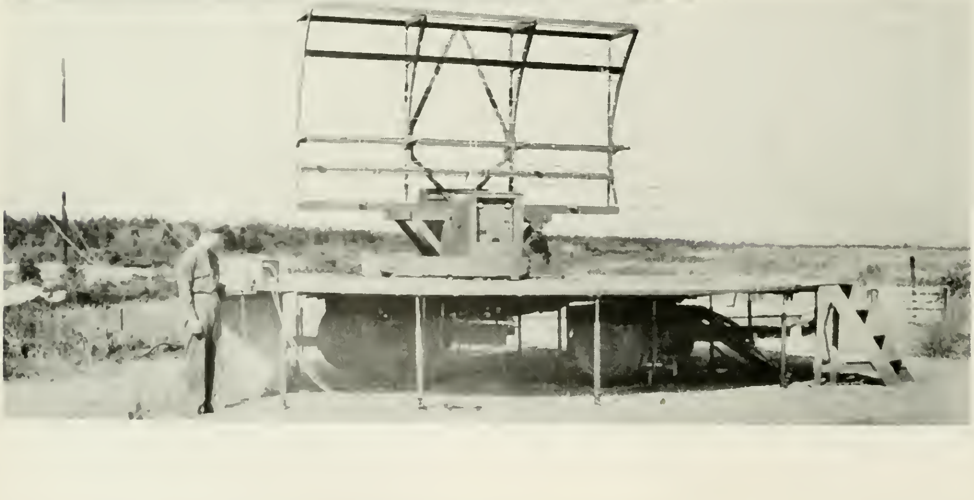
As the war drew to a close, speculation arose as to the peaceful uses of radar. It is perhaps fair to say that radar, as radar, will have an immediate and beneficial effect by adding to the safety of air and sea travel. But the impact on electronics of techniques developed during the war may well outdistance such applications by influencing developmental trends in innumerable articles manufactured for better living. Radar made the electronics industry one of America's major ones, now comparable in size to the prewar automobile industry. This new industry can be expected to create, through its enormous laboratories and factories, new channels of commerce and new opportunities in many different directions.

RIGHT: Radar's predecessor, the sound locator



LEFT: Close-up of the U.S. Navy's first radar, a "dirigible" antenna installed 'topside' the Naval research laboratory at Anacostia, D.C.

BELOW: The Army's first radar. This prototype of the famed SCR-268 radar is shown during its initial test in the late 1930s

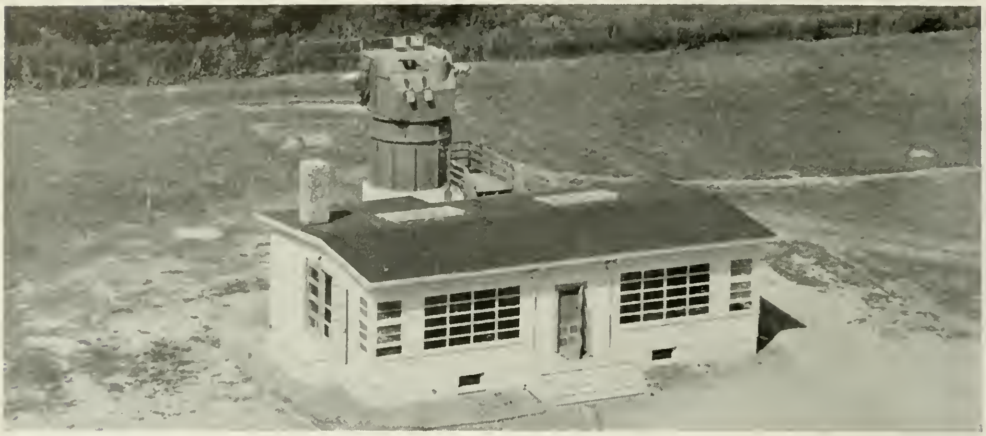


Maj. Gen. Roger B. Colton (Ret)

Dr. A. Hoyt Taylor

Radar's Inventors

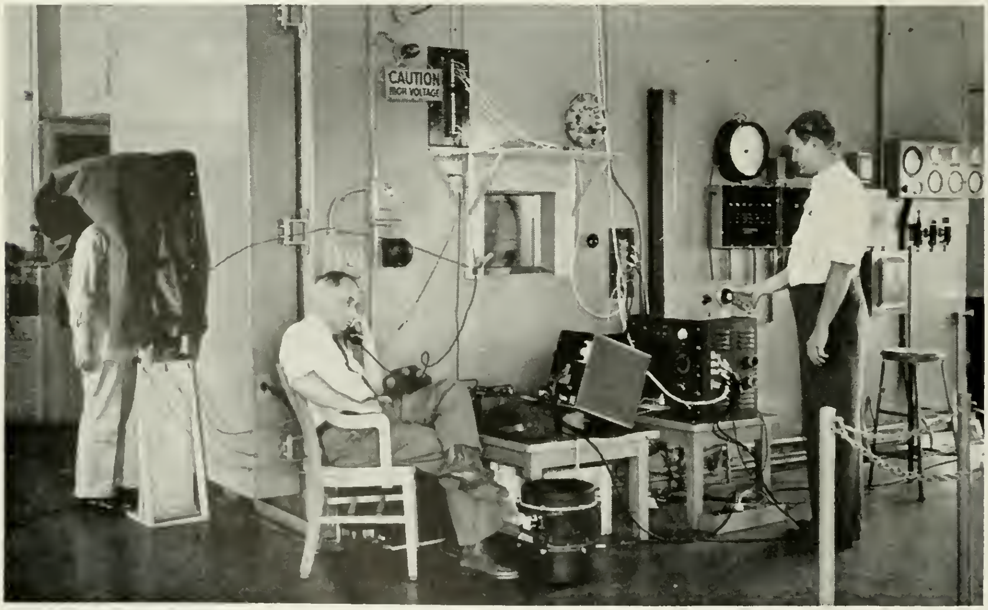
Who invented radar? This question arises again and again. Like all exceedingly complex achievements of the present technical age, radar owes its greatest debt to the great physicists of the preceding centuries, including Newton, Maxwell, and Hertz. But among contemporary workers, whose genius turned obscure principles of science into telling adjuncts of modern warfare, a few names deserve special mention. These include Britain's Sir Watson-Watt; the Army's Maj. Gen. Roger B. Colton (Ret.); and Dr. A. Hoyt Taylor, who, as chief consultant and chief coördinator of electronics at the Naval Research Laboratory, Anacostia, D.C., made an initial discovery in 1922 which proved that radio echoes could one day, with the speed of light, serve to locate and range targets.



ODD ASSOCIATES: a neat cottage and a battleship's fire-control turret. They were among the structures which housed Bell Laboratories radar research

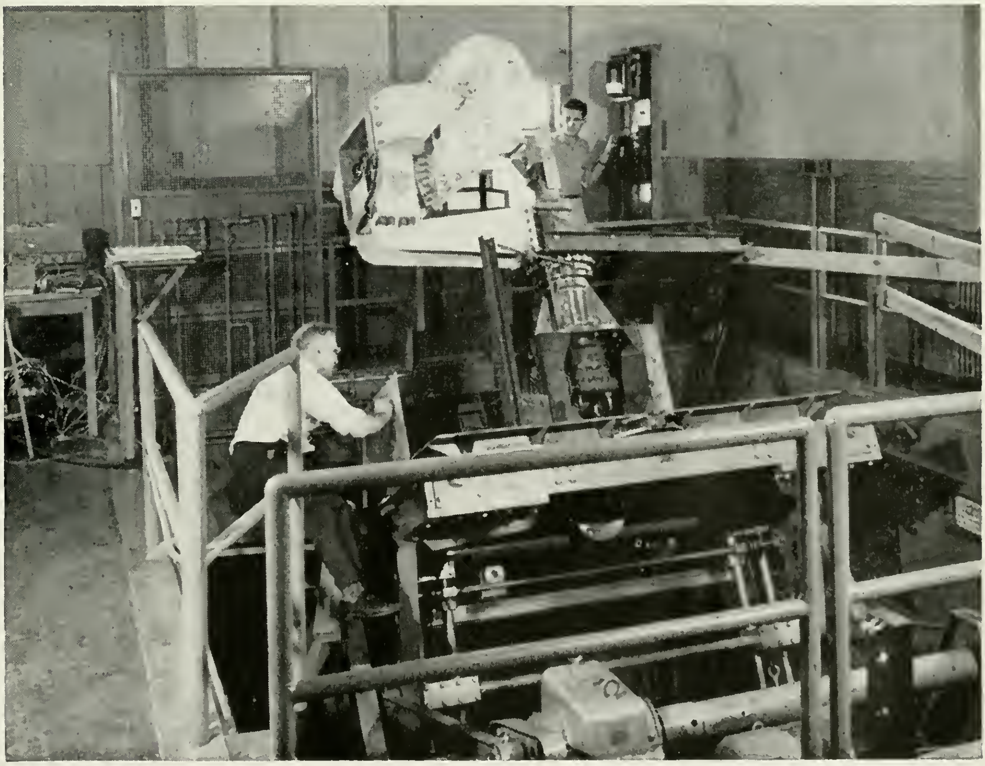
Radar Development

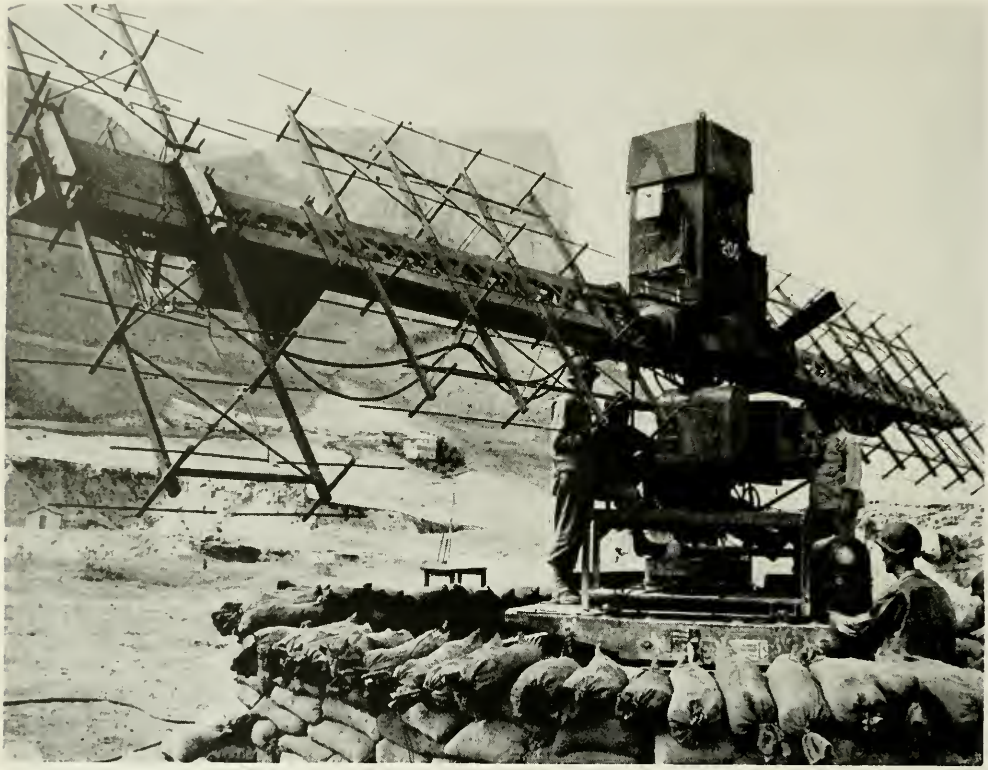
BELL TELEPHONE LABORATORIES and the NDRC Radiation Laboratory at the Massachusetts Institute of Technology shared leadership in radar research and development. Approximately half of Bell Laboratories' research effort during the war was devoted to radar and its contributions exceeded those of all other industrial laboratories combined.



INSIDE THIS "weather box," radar developments could be subjected to temperatures ranging from the bitter cold of polar nights to the humid swelter of the jungle

Above: An experimental radar spots its first test target. Below: This testing machine simulates the pitch and roll of a storm-tossed fighting ship





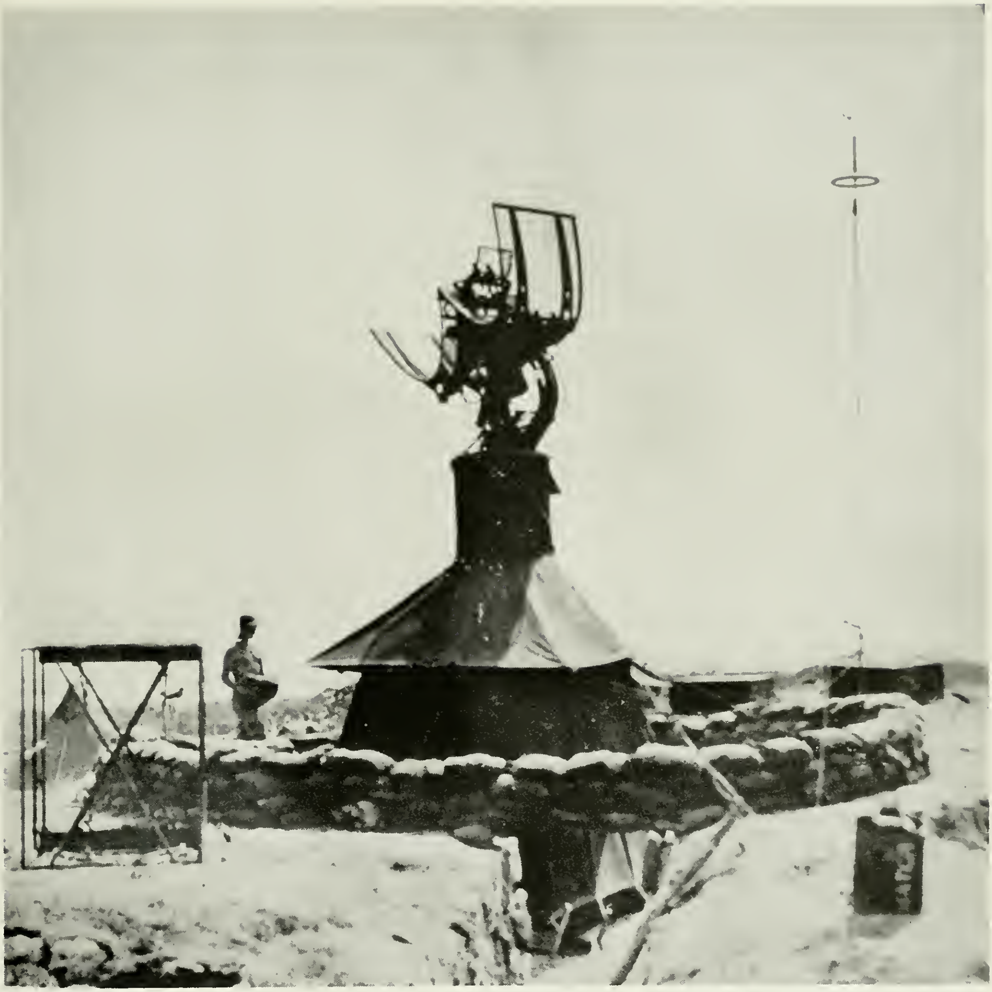
An SCR-268 radar on guard near Naples during the Italian campaign

Radar—Its Test in Battle

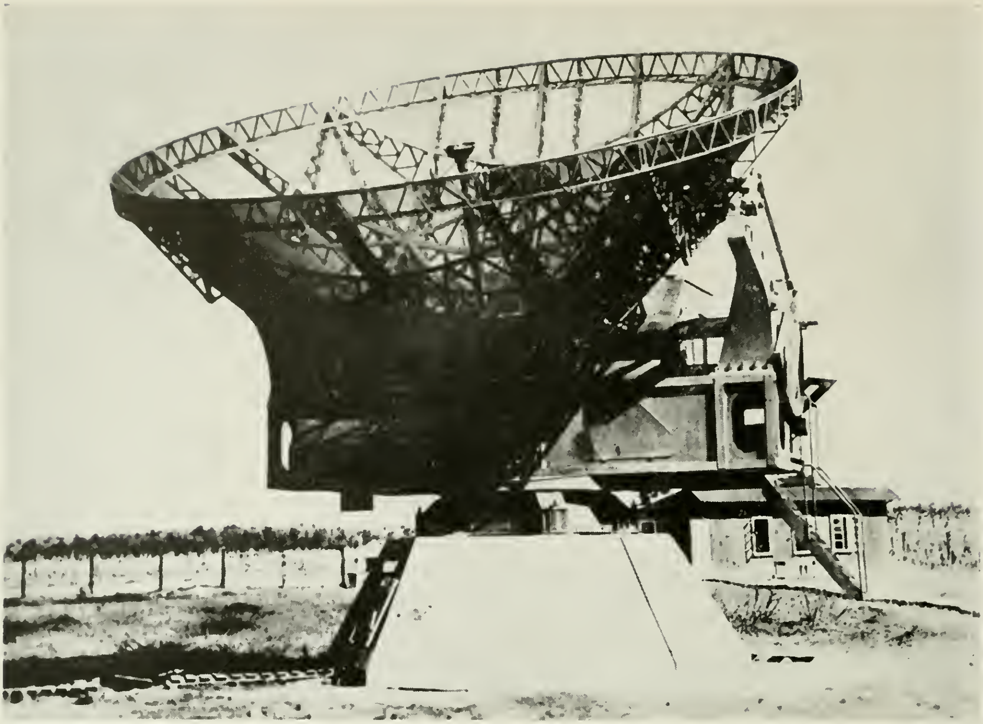
The assaults on England by the Luftwaffe, which the British had anticipated for so long, began on August 8, 1940, and rapidly increased in intensity. The first raids were directed at RAF bases, but by September the mass raids on London had begun. England's defensive radar chain was to have its first great test. Strangely, it seemed to the British, the Germans attached no importance to the stations, although the great masts which marked each radar site afforded an unmistakable target.

Despite a critical shortage of fighter planes and pilots, the British were able to spot each incoming raid in time to throw fighters against it. The necessity for constant airborne patrols of fighters was removed and the few to whom so many owed so much were thrown into battle economically and with maximum effect. Germany suffered her first great defeat of World War II.

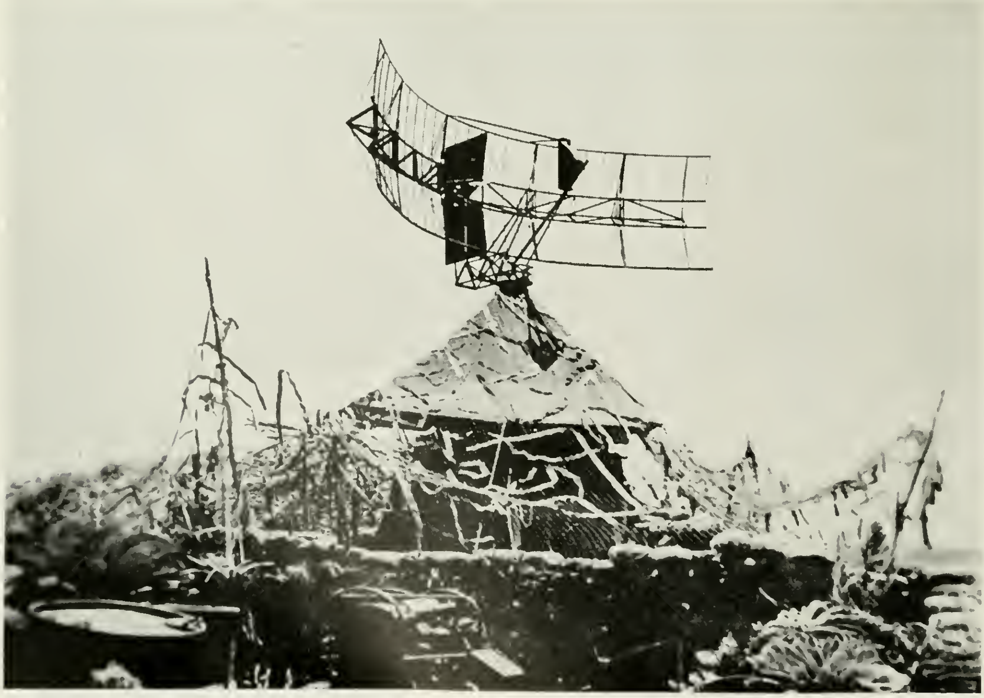
The battered Luftwaffe retired behind the Siegfried Line to lick its wounds, while Allied science and industry, urged on by the military, embarked on an ever-expanding program of radar production which was destined, more than any other material factor, to end the Axis dream of conquest.



Model O radars, with cradle-like antennas pointing seaward, stand watch on Okinawa

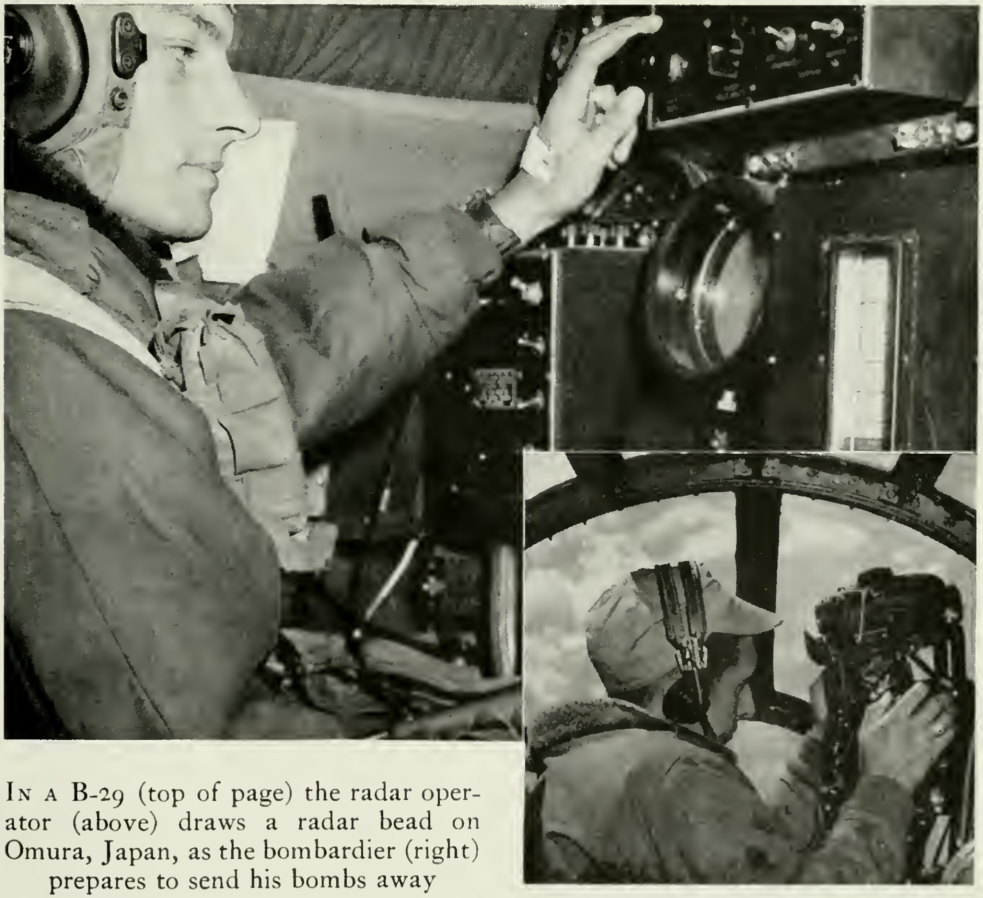


The unwieldy "Giant Wurtzburg" (above), a German counterpart of U.S. land radar. Contrast it with the light, easily camouflaged U.S. search radar shown below

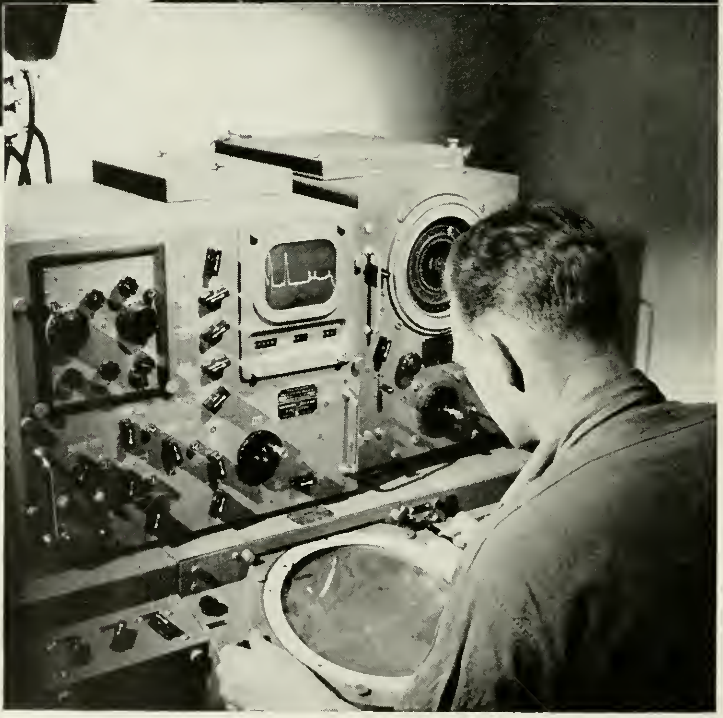


Radar in the Air

AMERICAN PLANES used radar for navigation; for searching out the enemy and following his movements; for intercepting his planes and directing our planes' attack; for fire control of our planes' guns; and, in addition, for both tactical and strategic bombing.



IN A B-29 (top of page) the radar operator (above) draws a radar bead on Omura, Japan, as the bombardier (right) prepares to send his bombs away



ABOVE: Action in the plotting room of a major fleet unit during the attack on Mili

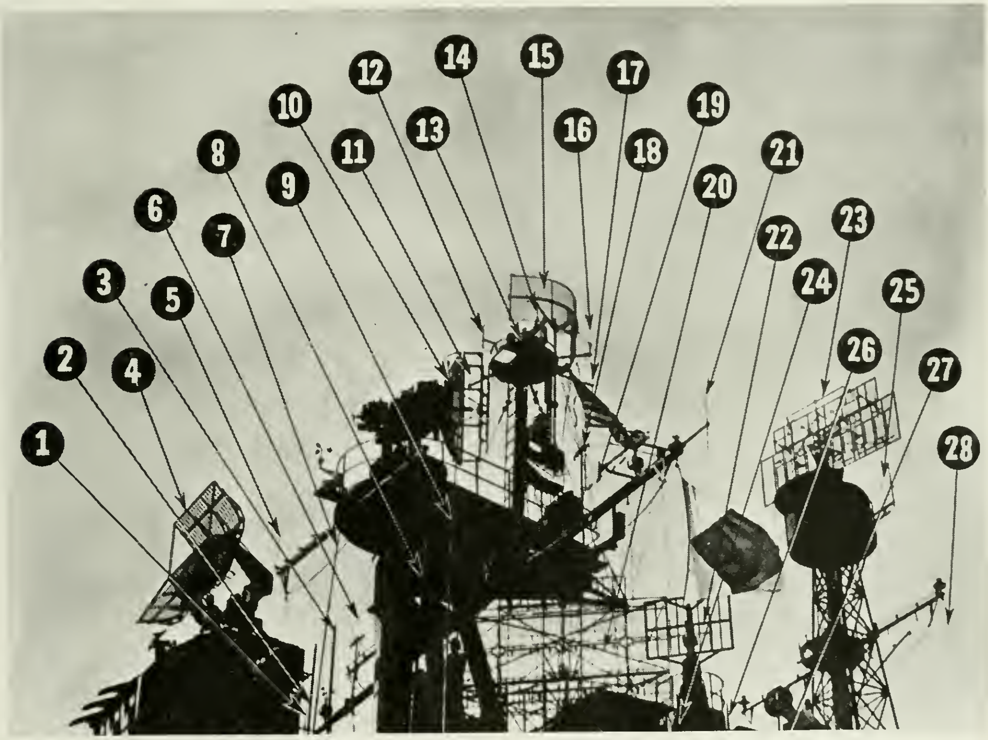
RIGHT: The wiggly line on the "A" scope (top center) shows the range of four targets

Radar at Sea

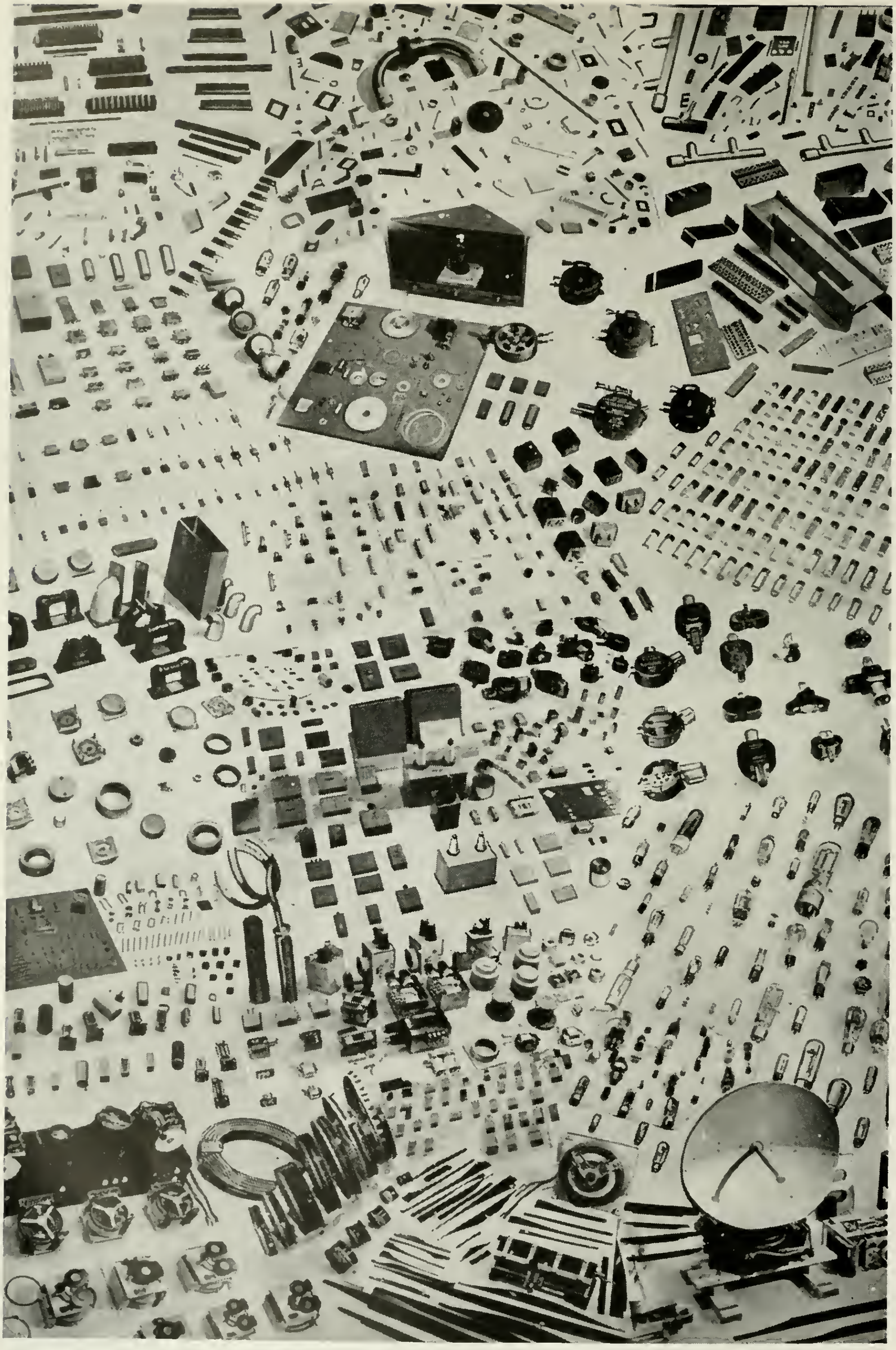
TECHNICAL COMPLEXITY, which for hundreds of years has characterized sea warfare, reached new heights in the plotting rooms of fighting ships during World War II. By radar, skilled officers recorded the positions of their own ships and planes as well as those of the enemy.

Eyes and Ears of a Carrier

THE EXTENSIVE USE of electronics in World War II is reflected in this complex array of antennas atop the "island" on a modern giant of our aircraft carrier fleet. In this view, at least 28 radar and radio antennas of different shapes and sizes are outlined against the sky. These may be identified by the corresponding numbers listed below. Circled in the picture of an Essex-class carrier at the bottom of the page may be seen the identical area shown in the upper photograph.



1. Radio communications
2. Radio communications
3. Radio communications
4. Fire control radar
5. Radio communications
6. Radio communications
7. Radio communications
8. Radio communications
9. Radio communications
10. Air search and height finder radar
11. Radio communications
12. Radar test equipment
13. Surface search radar
14. Radio communications
15. Radio homing beacon
16. Radio communications
17. Radio communications
18. Radio communications
19. Radio communications
20. Air search radar
21. Radio communications
22. Radio homing beacon
23. Air search radar
24. Radio communications
25. Identification radar
26. Radio communications
27. Radio communications
28. Radio communications

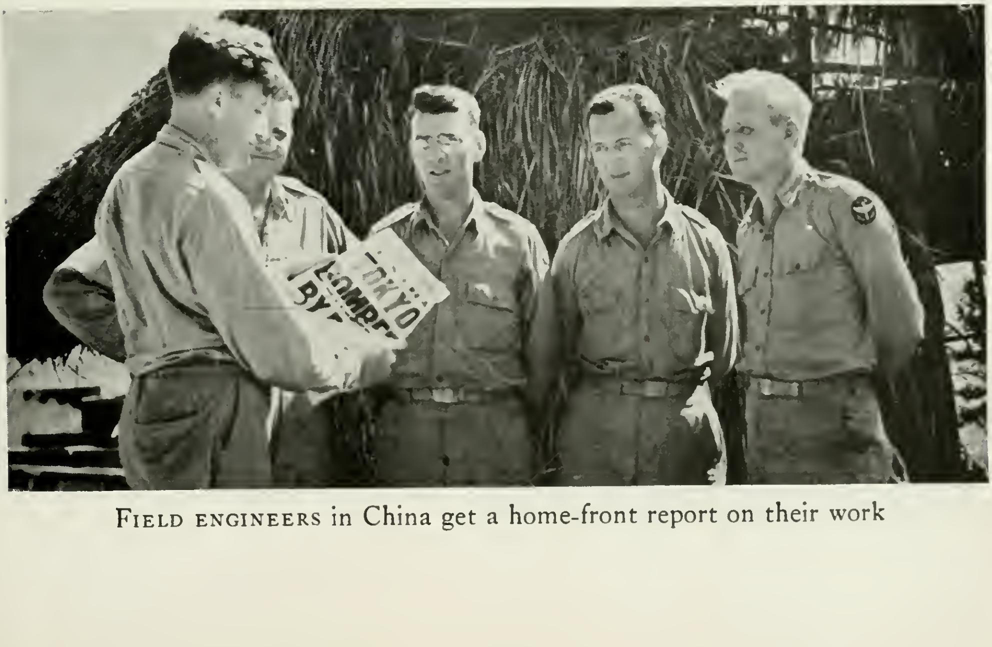


A MANUFACTURER'S-EYE VIEW OF RADAR

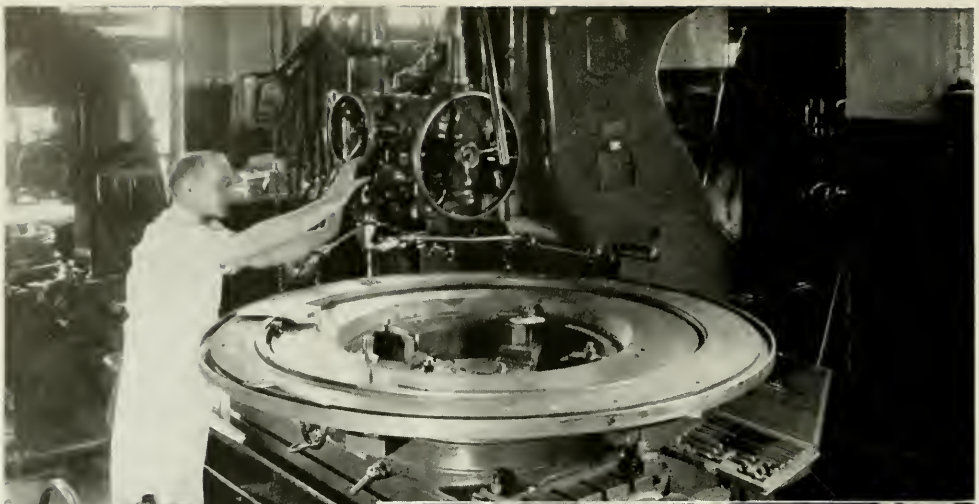
Office of the Engineer of Manufacture, Special Products Building, Point Breeze

Radar—and the Engineer

Of necessity, radar required an enormous concentration of engineering talent. In addition to the thousands employed by home-front laboratories and factories, more than 500 Western Electric and Bell Laboratories engineers followed the equipment into forward military areas. By the war's end one was aboard every major unit of the fleet.



Field engineers in China get a home-front report on their work



Jig boring

Heat treating

Industrial bombsight

Radar Tooling

RADAR required many tools and fixtures unlike those utilized for the production of telephone equipment. More often than not, standard tools did not exist for the job. This meant the design and manufacture of new tools, a significant number of which were produced in Western Electric's own tool rooms.

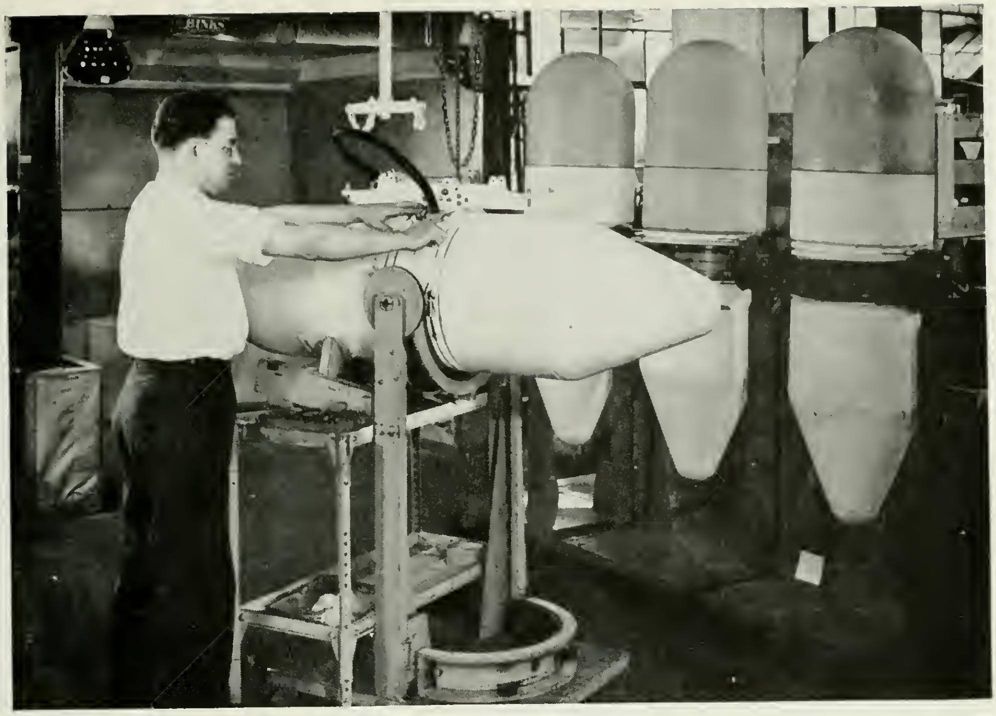
THE ASSEMBLY of precision radar components required clean, well-lighted rooms

The "Ash"

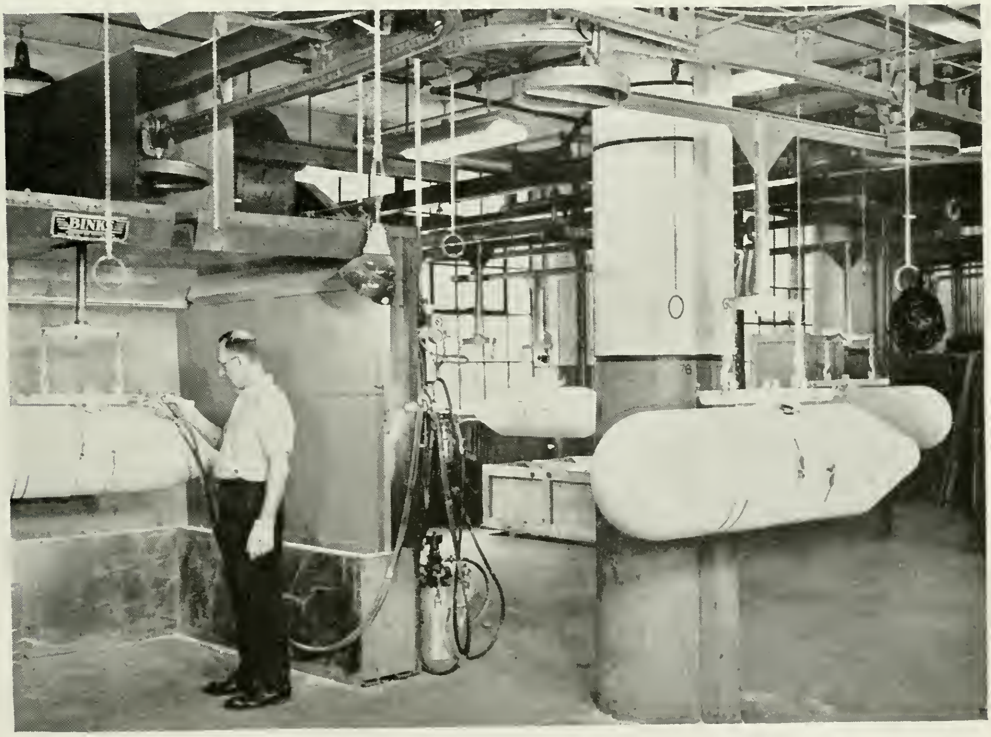
"GIVE US a lightweight radar," demanded the Armed Forces, "one which can be installed quickly beneath the wings of our fighters. It should spot targets clearly up to twenty miles or more. It should weigh less than a man. Means should be provided so that it can be dropped at the touch of a button during the heat of combat. Its design should anticipate quantity production, widely divergent application, and easy maintenance." Bell Telephone Laboratories answered with the bomb-like ASH. A contract dated June 6, 1943, the largest single order received by Western Electric during the war, called for 12,500 ASH radars. This was but one of four contracts for the project, which continued through V-J day. The ASH was manufactured by Western at Hawthorne's Kolmar Avenue shop. The techniques devised for its production are representative of the most advanced practices found in American industry.

FINAL assembly and wiring of the ASH

TESTING transmitters and high voltage power-supply sets

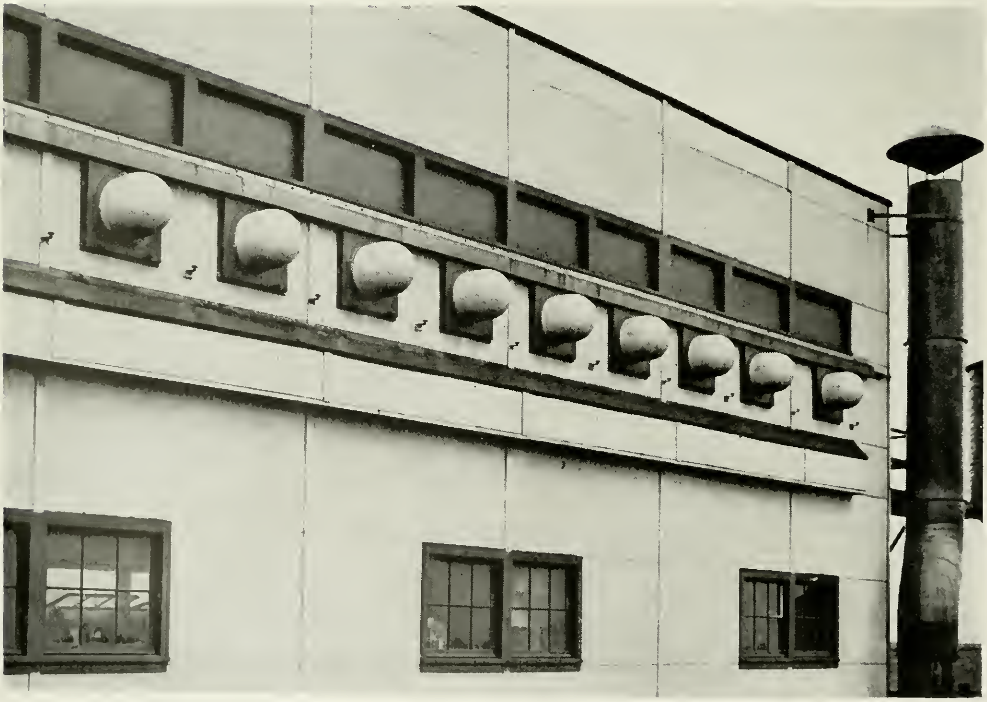


MAKING final adjustments of the suspension mechanism

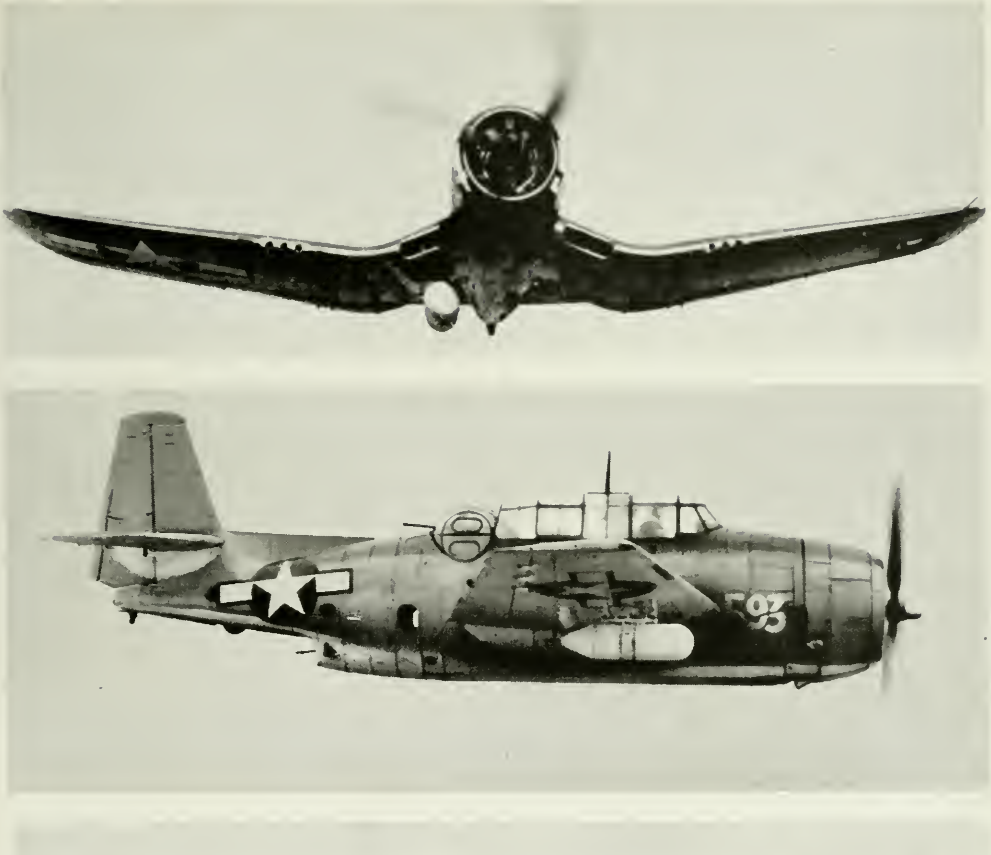


SPRAY painting the ASH

In this final test room the ASH gets its first look at Chicago



Radomes of ASH radars on test overlook Chicago targets



THE ASH as carried by three types of planes: a F4U-1D fighter; an Avenger torpedo bomber; and a Navy PTR

Kearny women made precision bombing radars for the B-29s

Hawthorne women assemble "range" units for ASH radar

These Women Made Radar

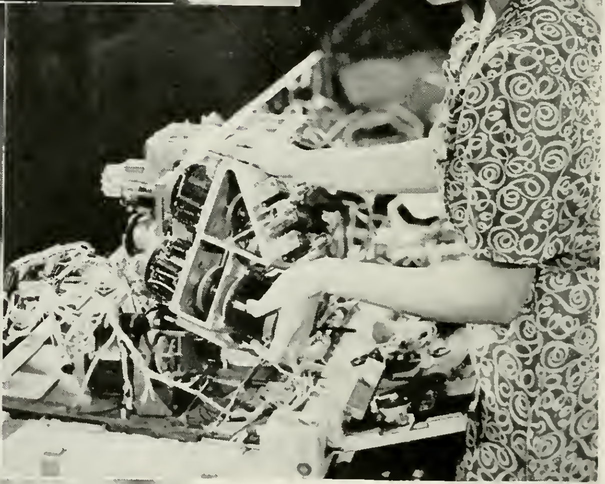
The manufacture of 57,000 radars, in addition to other Western Electric war work, meant doubling the size of the pre-war organization and integrating tens of thousands of new, untrained workers into a unit of long and specialized experience. That these newcomers to the ranks, most of whom were women, adapted themselves quickly and earnestly to new habits of work and helped the Company to break all previous production records stands as a great tribute not only to them but to the long-service employees whose coöperation the new workers so richly returned in kind.

Drilling

Heat sealing

Antenna wiring

Adjusting



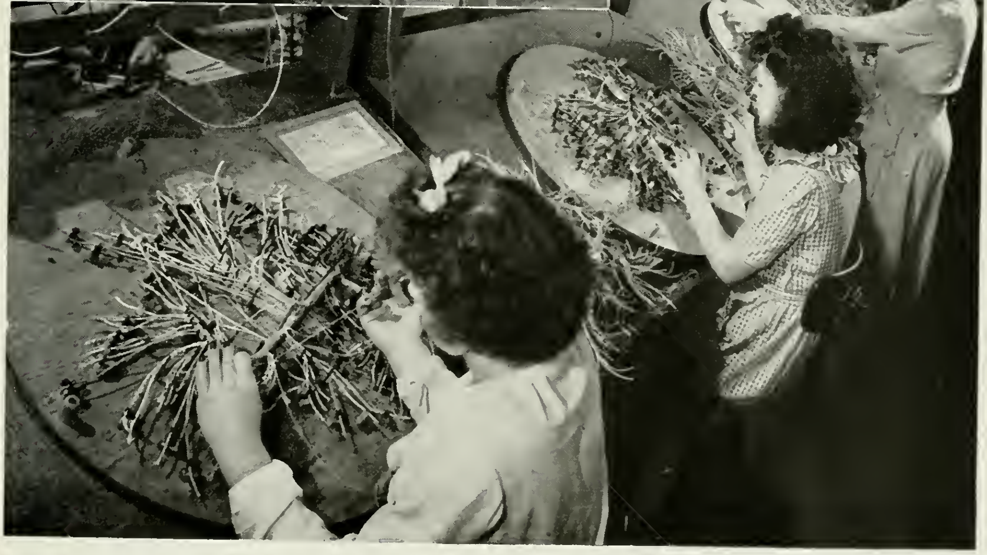
Apparatus assembly

Piece part assembly

FINAL INSPECTION

TEST SET INSPECTION

ROTATING "clip" board speeds cable forming



R. D. R.

A SHIPPING CASE encircled with a red band bearing the magic initials "R.D.R." became an object for top priority handling among merchandise and transportation experts during the war. Radar (R.D.R.) did not always leave the shipping platform in a box, however. Often long caravans of self-propelled radars left the factory surrounded by armed guards and with WAC drivers. The packaging of radar called for the utmost care and ingenuity because safe delivery required the shipment withstand every known hazard of transport and climate. Military men admonished those who packed radar, "Remember, upon arrival a radar is no better than the box it comes in."

PACKAGING B-29 antennas in airtight bags

DOUBLE-PACKING parts in cardboard containers. Below: drive-away delivery of radars

Overcoming Problems of Manpower, Materials, Facilities, and Experience, the Bell System's Manufacturing Affiliate Became the Nation's Largest Source of Radar

Radar and Western Electric

Frederick R. Lack

One afternoon in the early Fall of 1940, a woodworker in the Queensboro plant of the Western Electric Company on Long Island fed a big slab of plywood into the whining teeth of a power saw. Probably no one at Queensboro, where the sounds and sights and smells of woodworking are a commonplace of life, realized the significance of that historic moment. Yet, as the first manufacturing operation on the first radar piece part, it marked the start of the greatest task ever undertaken by the Company—the supply of nearly a billion dollars' worth of radar and accessory equipment for World War II.

Before many months passed, the demands of the radar job permeated the Company's entire organization, even though few people knew that such a device as radar existed. Under a blanket of military secrecy the work fanned out from Kearny to Hawthorne, to Point Breeze and, eventually, spread into leased quarters scattered half way across the country. But such was the size of the undertaking that even these facilities were not enough. So, the Company enlisted the coöperation of sub-contractors—at first a few, then hundreds, and finally thousands.

Given a preparation interval commensurate with the magnitude of the job, radar would not have proved more difficult to manufacture than telephone equipment. The new technical elements introduced by radar are, of course, complex. So are those found in a modern telephone central office. The manufacture of both requires techniques and processes of great exactness. But this was war, and time was of the essence. Years had to be compressed into months and months into hours. Allied war leaders promised the continuous, 'round-the-clock' bombing of the enemy—an enemy screened, the greater portion of the time, by darkness or heavy blankets of cloud. Victory, and the lives of thousands of our men, hinged on the penetration of that screen by radar without delay. This was the urgent necessity. This was Western Electric's time table.

A MANUFACTURER'S capacity to produce can be measured in terms of four interdependent elements: manpower, materials, facilities, and experience. When Western Electric was asked by the Government to undertake the manufacture of radar, the Company was more than adequately endowed with all these essentials.

It had on roll a total of 43,500 people. Its warehouses, and those of its suppliers, were stocked with just about every substance for which the mind of man had contrived a use. At its disposal were 198 acres of manufacturing space. For almost three quarters of a century, the organization had practiced the specialized arts and crafts of fine electrical manufacture and the Company took pride in the fact that throughout its history it had concentrated on manufacturing for maximum service.

Given anything like "normal" conditions for its work, the Company could count on a production potential of some $400,000,000 annually. The earliest orders for radar amounted to a mere fraction of this and, therefore, aroused no more than a flicker of interest in a few specialized departments, which were already heavily involved in building radio telephone sets for the Air Force.

Then the flood gates broke. Wave after wave of orders for equipment swept in, calling for radar of many types. The Government found in the Western, and its research and development associate, Bell Telephone Laboratories, two qualities almost unique in American industry: the ability to design and produce the precise mechanical and electrical elements required by radar; and the facility quickly to change and adapt manufacturing techniques in pace with the rapid advances of the new radar art.

The Size of the Job Which Western Did

A BRIEF GLANCE at some of the statistics of the radar job indicates the vast proportions of the undertaking.

During the war years, the Western supplied the Government with more than 57,000 radars, of 70 different types, valued at nearly $900,000,000. The Company was the nation's largest source of radar, and in dollar volume it supplied the Government with half of all the radar made in the United States. In the peak year of 1944 the Western supplied 22,000 radars, worth $340,000,000.

During the war period, the Company supplied more than 5,000 radars for use on the ground alone. Some of these were huge affairs filling several truck and trailer units which weighed up to 70,000 pounds and contained enough power generating equipment to light a small city. More than 6,000 of its radars went aboard the Navy's fighting ships where, among other functions, they pointed all of the big guns and directed the aiming of our submarines' torpedoes. Forty-six thousand went aloft with the nation's air forces, including those which the big B-29's used exclusively for precision radar bombing.

The story of radar's development and refinement is told in a companion article beginning on page 221 of this issue. That story, like the one chronicling radar manufacture, spans a peak interval of less than five years; yet such was the activity of those years that what began as a vague hope in the minds of a handful of Army and Navy officers emerged as a multi-billion dollar enterprise with all the careful controls of a long-established industry.

"*Sign Here . . . and Go to Work*"

For Western Electric, the story began in the late summer of 1938. A small group of engineers from Western Electric and Bell Telephone Laboratories visited Sandy Hook, at the invitation of the Signal Corps, to inspect a radar on test at Fort Hancock. The experimental model had been constructed under the far-seeing leadership of Col. Roger B. Colton (later a Major General and now retired) who, overcoming many discouragements and disappointments, was finally able to demonstrate the feasibility of building a mobile unit which could be used by troops in the field for detecting and ranging an airplane by electronic methods.

Impressed with the soundness of the idea, the visiting engineers promised their coöperation in furthering the development. Over the succeeding two years, they found numerous occasions for lending encouragement and active support to the project—although no formal agreement between the Government and the Company existed. That was initiated on August 23, 1940.

The afternoon was hot. Once again, at the invitation of Col. Colton, the engineers had assembled to witness the test of an Army radar—this time the model destined to become the famed SCR-268. Opportunities for additional improvement suggested themselves to the engineers that afternoon; but authority to proceed, and the necessary funds, were missing. Col. Colton drove back to the administration building and the session drew to a discouraging close. Just as the party was preparing to leave for the day, a familiar blue coupé bearing two officers dashed down the dusty roads of Sandy Hook and came to a grinding halt. "Come here!", yelled the driver Capt. (later Colonel) Rex Corput.

As one of the engineers approached the car, its other passenger, Col. Colton, thrust a large double sealed envelope from the opened door.

"Sign here, my boy, and go to work," he commanded.

Going to work meant, first of all, a further series of conferences between the technical personnel of the Army, the Western, and Bell Telephone Laboratories; the completion of a final design; and the manufacture of a preliminary model. Simultaneously, as information became available, work was started on the manufacturing analysis, a painstaking process of answering with accurate written orders and drawings such questions as: How many machine tools, jigs, and fixtures will the job require? How can the available space be utilized to effect the smoothest production flow? What kinds and amounts of raw material? What manufactured materials and from what sources? How many men and women, and of what skills?

Although few people associated with the project understood its precise nature, all were conscious of its importance to the Government. The period of the "phoney war" in Europe had ended and President Roosevelt had proclaimed a state of national emergency. Things moved rapidly, and before many weeks the new radar makers succeeded in nursing their first production model through its myriad of detail.

LATE ONE afternoon the first SCR-268 made by Western Electric arrived for test at Fort Hancock—protected from prying eyes beneath a shroud of canvas and surrounded by an armed guard. In the meantime, at the Government's request, the Company had erected half a dozen wooden buildings on the military reservation, and the first radar was wheeled into one of these by a group of eager though nervous engineers. By the time all the gear was unlimbered, external electrical connections made, and the covering removed, the day had drawn to a close. Normally, the men would have gone home.

But excitement filled the air and work continued in the half-light of the early evening. Last minute adjustments were carefully rechecked. Then three men climbed the iron steps and settled themselves in the big bucket seats. Azimuth and elevation wheels began to turn. The great antenna swung slowly in the direction of Brooklyn.

Finally, with everyone holding his breath, the main power switch was thrown. A faint musical hum rose from the equipment, and everyone sighed with relief that there were no internal flashovers. Then, after a moment, a thin, jagged line of brilliant green darted across the face of each "scope."

"Look," exclaimed a nearby G.I., "a target . . . at . . . at . . . 44,000 yards! It must be the Coney Island gas tank."

The first W.E. radar was "on the air."

More than 2,000 of the old reliable 268s were to fight valiantly in World War II. They went ashore with the G.I.s at Guadalcanal and North Africa. Their lightning-fast waves echoed through the rugged terrain of all southern Italy. The Spring of 1945 found them helping to guard the Remagen bridge, and even today their silent watch continues over American outposts scattered throughout the vast Pacific area.

Engineering Was Never Finished

GERMANY tried to blitz her way to victory by hurling huge masses of men and machines against the Allies. She achieved the great initial production essential to this strategy through the expedient of freezing designs and employing static processes. To her leaders, this seemed a reasonable policy. But, in the end, it proved a major factor in her defeat. In contrast, our Armed Forces demanded "better and better" as well as "more and more."

Accordingly, the average life of a Western Electric radar project spanned less than a year. Even during this short interval, thousands of detail design changes were handled on a single project and, as a result, engineering was never finished. Each radar design required a sizable engineering staff until the last equipment was shipped. Antenna spinners, for example, which are devices that help to shape radar waves into a pencil-like beam, were under constant change as the engineers sought to improve their useful life and to achieve a clearer, sharper representation of the target on the viewing scope.

Each of these thousands of design modifications, even those of a minor nature, caused, in general, other thousands of changes in the elemental manufacturing operations—or in the timing or grouping of those operations. Each change meant new manufacturing layouts, the need to relieve resulting work pile-ups along the assembly line, the necessity of acquiring new skills, new work habits, or—in extreme cases—new personnel.

The Infinitude of Radar Parts

RADAR appears different to the eyes of each beholder. To the fighting man of World War II, it was a weapon of imperative necessity. The public saw it as a dark miracle wrought by the magic of science. To the manufacturer, radar was an overwhelming complexity of intricate piece-parts.

These parts range in size from carefully fashioned microscopic specks to great castings taller than a man. Some radar designs called for assembling as many as 7,000 interrelated parts into a space no larger than a hat box. Other radar mechanisms, of the same size, demanded voids as empty as the space between the stars.

It is only by thinking in terms of these numerous and varied piece-parts, and the many individual manufacturing processes behind each one, that the true perspective of the Western Electric radar project begins to emerge.

Size, or even apparent simplicity, is no index to the complexity of a part's manufacture. For example, one vacuum tube, known to engineers as a "cavity magnetron," requires a short stubby tube of copper, the inner surface of which is uniformly pierced by a series of slots resembling precision-cut keyholes. In one model, the tube is no larger than a lady's thimble. Yet its formation required 58 separate operations. Even the metal cabinets which house the radar parts can prove deceptive to the casual eye. Many of the cabinets resemble those which cover the mechanism of teletypewriters. What appears as a simple, *single*, teletypewriter cabinet is actually made by punching, cutting, drilling, stamping, bending, forming, inspecting, assembling and finishing 225 separate parts!

What Those Parts Are Made Of

RADAR was assembled in a great variety of containers: some in pressure-tight castings; some in light aluminum boxes; and some composed of strange new materials transparent to radio waves but air- and water-tight. A long and exciting story might be written of the successful search for this substance. When finally discovered by engineers of Bell Telephone Laboratories, and fashioned with the help of the men and women of Western Electric, the performance of the new material more than justified the long search. In one form it became the "nose" of the deadly "Bat", a radar-controlled bomb which sniffed its way unerringly to Japanese shipping when loosed in the vicinity of the target by American airmen.

Many of the raw materials from which radar parts are made are fabricated in the Company's own shops. Magnetic materials, particularly of the family known as "permalloys," are produced in large quantities. Including the non-ferrous metals and their alloys—brass, bronze, nickel-silver and the like—the capacity of the metals manufacturing plant, while small compared with plants devoted exclusively to the business, amounts to 1,250,000 pounds a month.

In this same plant precious metals, measured in fractions of an ounce instead of pounds—such as gold, silver, platinum and others—are reclaimed for re-use and then recombined. To the casual visitor examining one of the products, what at first may appear as a coil of light wire may prove on close inspection to be a thin bi-metal tape composed of gold worth $35 an ounce welded to a heavier thickness of nickel worth 35 cents a pound. Such tapes permit the current-carrying springs of radar to make and break the electrical circuits without burning away in the resulting arc.

Another materials shop essential to radar manufacture specializes in ceramic products. Most of its products were developed to satisfy the Company's own exacting requirements: jewel-like colored glasses, porcelain, glazes for porcelain and metal, and materials of low electrical loss for use at the high radio frequencies demanded by radar applications.

Space does not permit even a highlight listing of all the raw material products or the shops which manufacture them. Some materials are extremely rare and have long names comprehensible only to chemists, others are as common as clay and enter into the manufacture of apparatus familiar to every telephone user.

Use of Standard Parts

STANDARD telephone apparatus, incidentally, served radar with great distinction along with more exotic components. Every system left the shipping platform with a full complement of jacks, plugs, keys, and relays. The same old reliable jacks, plugs, keys, and relays so familiar to all telephone people, they came to be the building blocks of radar.

As every telephone man knows, such apparatus must be adjusted and otherwise serviced with the help of special tools ranging from odd-shaped screwdrivers to "feeler" gauges. In the final year of the war alone the Company supplied the Government with approximately 1,000,000 of these tools made up in 150 different designs, a substantial portion of which was employed for radar servicing.

Another important class of apparatus, common to both radar and the telephone, is the repeating coil transformer or "choke". A properly designed coil of copper wire does much the same kind of work in a radar circuit as that of a wheel in a machine—it helps, among other functions, to keep the machine running smoothly and enables power to be transmitted effectively from one part of the mechanism to another. During the last full year of the war the Western made 9,300,000 of these "electrical wheels," valued at $42,000,000, and, in addition, purchased 3,000,000 more from other manufacturers. Only part of them went into radar; yet the consumption of radar coils ran into millions.

So great did the need for coils become that a special coil shop was established in a former shoe factory at Haverhill, Mass. The project was undertaken with only a skeleton force of experienced people, who then trained 2,000 others recruited locally. In a few months the new shop was winding, insulating, potting, and testing some 8,000 types of standard coils. Within a year 770 new kinds of coils were introduced into manufacture.

Many of these new coils were exceedingly complex. A simple coil of open construction had formerly been used in one part of an airborne radar circuit. This coil had the advantage of light weight, small size, and low cost; but it had the disadvantage, under tropical conditions, of susceptibility to moisture and fungus growth to a degree which could not be tolerated. Weight considerations precluded sealing it in a metal can. After an extended hunt, the Laboratories' engineers came up with a compromise. Beginning with talc (the base of face powder) and the oil of cashew nuts, they concocted a black viscous liquid. Large pumps circulated this between mixing vats and the tanks of a special dipping and drying machine.

An automatic conveyer transported the radar coils through the bath and an air drying cycle and finally delivered them to a constant-temperature oven. In this oven, the chemistry of the black liquid underwent a radical change, which engineers call polymerization, and the light-weight coil emerged, still a light weight, but incased in a thin though amazingly tough armor—a match for the climate of any battle area.

In all, Western Electric set up 16 satellite plants in nine cities to assist its main plants in turning out land, sea, and air radars of seventy different kinds ranging in size from huge multi-ton jobs to those for aircraft weighing no more than the pilot of the plane.

In Baltimore, the broad interior of a former airplane factory soon became an orderly patchwork of work benches, office areas, engineering cubicles, and tool cribs. Carloads of raw material entering the hangar on one side rolled out the other as giant ground radars, each supported by 30 heavy truck tires.

The former shoe factory in Haverhill shared its radar load with a former laundry in Jersey City, and with what had been an ordnance plant in Eau Claire, Wisc. Ex-garages, warehouses, engine-parts plants—almost any building with a roof that did not leak, or which had one that could be repaired—qualified as a radar shop if the community could provide people enough to staff it with workers. By the war's end the Company's total manufacturing space had increased to 329 acres.

Women Helped to Solve the Manpower Problem

The necessity of recruiting and training additional manpower to meet the demands on Western by the Services was felt early in the war. Sufficient men, with or without manufacturing experience, were not available. Hence the Company turned to women.

In 1873 Western's first woman shop employee took her place at the work bench. Through the years her numbers grew, and by 1941 the Company could take pride in the fine record of accomplishment made by three generations of women employees. In 1941, women comprised about 20 per cent of the total employment. At the time of maximum wartime employment, August 1944, when the total reached 97,416 employees, the proportion of women had increased to 60 percent. At no time during the war did the number of male employees rise substantially above the peacetime figure. In effect, men employed and trained for radar production and other war work served as replacements for the 28,000 released to the Armed Forces and Merchant Marine.

THE THOUSANDS of newly employed women who made radar ranged in age from schoolgirls to grandmothers and in experience from housewives to actresses. Prior to the war, few of them had ever visited a factory, much less worked in one.

Although no set formula exists either for removing the complexity from a strange piece of radar gear or for endowing a pair of unskilled hands with the deftness of long practice, the Western's manufacturing engineers found that almost anyone can learn quickly to perform three or four simple operations, particularly if the same sequence is repeated over and over at intervals of about a minute or so. To utilize the services of these new people effectively, the Company intensified two long-established programs; one involved work simplification, and the other, training.

To qualify these untrained women for radar production, therefore, the Company's engineers analyzed, grouped, and timed all of the elemental operations through which bits of raw material became finished piece parts. Then, step by step, they continued the process as piece parts merged to form sub-assemblies, as sub-assemblies combined into final assemblies and the whole finally evolved as an enormous complex of electronic fighting gear, tested and often packed specially for duty overseas.

The Importance of Sub-Contracting

IF, EARLY IN THE WAR, the Company had not undertaken a far-sighted program of sub-contracting, it would have been swamped by the influx of Government orders. To facilitate sub-contracting, each major Western Electric location surveyed the manufacturers in its area to ascertain the type of work for which they were best qualified. The surveys covered more than 6,000 firms: a few very large ones, and the remainder employing from one or two people to several thousand.

To most of the sub-contractors, radar represented a far cry from peacetime pursuits. A manufacturer of slot machines, for example, turned out a light-weight precision antenna for an air-borne radar. The manufacturer of cabinets to house the radar which controls the firing of the biggest guns on the heaviest battleships was formerly a maker of metal clothes lockers. The precision antenna drive for a large ground radar came from a maker of laundry machinery. A producer of pots and pans made tail sections for the bomb-shaped radar carried beneath the wings of air fighters. The metal frame for this same radar came from the shop of a bicycle manufacturer in Chicago. Finely made mechanical parts came, surprisingly enough, from a nationally known cereal firm, which maintains a precision machine shop for the peacetime production of packaging machinery. The requirements for aiming a large radar accurately are not unlike those demanded by astronomers of their big telescopes. The manufacturer of the mount for the giant 200-inch telescope atop Mt. Palomar made antenna mountings for Western's ground radars.

SUB-CONTRACTING, of itself, made heavy demands upon the organization. The Company found long ago that it is not possible to place an order either in its own shops or with another manufacturer and then merely wait for schedules to be met. During the war the meeting of Government schedules became supremely important. The Company would be told that a battleship intended to drop anchor in a certain harbor for repairs on a specified date. During the repair interval, usually short, the Navy wanted to install a new radar which would permit new and improved tactics on the next mission. Any failure to meet the delivery schedule on the new equipment might force the ship to rejoin her fleet without it and delay the use of these new tactics, with the possibility of losing all the advantage of surprise.

In embarking on its program of subcontracting, the Company made a careful study of each firm's qualifications: the nature of its experience, peacetime product, and plant facilities. Radar work appropriate to the firm's capability would then be allocated and Western would supply out of its own facilities and experience such help as the project required. Subcontracting thus became a matter of industry-wide team play, in which thousands of workers all over the nation pooled their skills and resources alike, to the end that Allied fighting men should bear arms of a quality second to none.

Many Western Electric engineers and production men were assigned to subcontractors' plants, and their assistance proved invaluable. In addition to the more conventional technical aid, these men spent many long evenings in plants waiting for parts to be produced so they could be raced by air through the night to some distant factory for the next step in the production process. Occasionally the job meant fighting bad weather and transportation delays. When the blizzard of 1944 tied up the freight yards in Cleveland, Western's men plowed their way through the bitter night, opened the stalled box cars, and after a long search located packages of parts required by a subcontractor the next day to fulfill an urgent war project.

Contouring the Cat's Whisker

SOME OF RADAR'S tools and processes proved startling even to Western Electric men of long experience. The contouring of the "cat's whisker," is a case in point. The rounded end of the cat's whisker, a tiny filament of metal thinner than a hair and only a fraction of an inch in length, makes contact with a pinhead speck of special crystal. The combination replaces a vacuum tube in the ultra-high-frequency circuits of radar and millions of them were required by the services.

The end of the cat's whisker must be pointed, but not sharp, something like the point of a slightly used pencil. If too sharp, the point bends or breaks. If too blunt, it presents an improper pressure to the crystal face, and refuses to work. Every stunt in the book was tried in an effort to produce just the right contour, but all ordinary methods failed. Finally, the engineers resorted to an old and almost forgotten trick of radio amateurs called electrolysis, an electrochemical process by means of which a metal can be quickly dissolved in a liquid through the passage of a carefully controlled current.

At first the idea seemed as simple and logical as a-b-c. Dip the cat's whisker into the solution, turn on the current, and let nature take its course! When all the metal disappeared except that covered at the surface of the solution, the job would be done. Unfortunately, there was a catch. The proper contour required an absolutely motionless liquid. And the liquid refused to stop jiggling.

The answer to this complication was found in 45 tons of concrete—sunk fifteen feet to bedrock and insulated from local highway and railroad vibrations. A 45-ton tool for a .001 ounce product!

RADAR'S high electrical frequencies—some measured in terms of billions of cycles per second—made the positioning of circuit elements extremely important. Deviations in the location of one part from its prescribed relationship to other parts may easily cause the values of a radar circuit to fall outside specified electrical limits.

Special tools were designed and built to facilitate the shaping of the lead wires which support resistors, capacitors, and other circuit elements of radar. These ingenious tools cut leads to precise length, produced the required bends accurately, and partially formed the connecting loops. Assembly and wiring operators found that parts so prepared could be soldered into correct position easily and quickly.

Moreover, with the aid of these tools, beginners could perform the precise cutting and bending operations. Thus, by building skill into the tools, the valuable time of many long experienced workers was conserved for other important essentials of radar wiring.

The Importance of Testing

THE STORY OF radar testing in itself could occupy many printed pages; for, regardless of the care with which the equipments are built, the exacting attention lavished on the preparation of manufacturing specifications, and the fabrication of parts and their assembly and wiring, the product remains an inert mass of parts until its various circuits have been carefully combed by ingenious test sets and subjected to the scrutiny of the expert testers who operate them. Whether in the factory or in the field, a blank radar screen may carry one of two interpretations: there is no target, or the system is not working.

In 1944 alone, Western Electric

produced more than 36,000 testing units for the Army and Navy, exclusive of the equipment used in the factories. These test sets were standard with the Services for use with systems of all makes.

The accuracy of some of this equipment defies comprehension. An oscillator, which generates electrical impulses of extreme rapidity, is made with such care that a clock of proportionate accuracy would run nearly a thousand years before gaining or losing a second. But, at the same time, an oscilloscope had to be produced which, dividing a millionth of a second into little parts, checked this extraordinary "clock" for errors! The only fact more astonishing, perhaps, is the realization that these sets are largely a product of feminine hands which, less than five years ago, were required to accomplish nothing more exacting than the artful application of make-up.

The Company's war record continues on and on with such examples of technical ingenuity. Yet, without one additional element, that record would mean little.

Throughout the war, military leaders reminded the home front that the pace of the assembly line, not the High Command, would establish "H" hour and "D" day. Battlefront strategy, they emphasized, began with manufacturing schedules.

Normally, such schedules are based on carefully compiled statistics. But radar was a new art. No time table had been written. Hence, the rule became—give the Armed Forces what they want *when they want it* and substitute determination for the missing figures.

The office of Western's president and the shipping platform alike obeyed the watchword: meet or *beat* the schedule! Each week on Tuesday afternoon, production heads would meet with the president to review the status of all projects and devise means for cracking stubborn bottlenecks. In office and factory, the men and women of the Company gave the best of their hands and brains so that no American fighting man should lose his life for want of a Western Electric radar that did not arrive on time.

The record for 1944 is typical:

DELIVERIES IN 1944 COMPARED WITH SCHEDULED COMMITMENTS

Class of Equipment	*Percent Realization*
Airborne Radar	102.6
Ship Radar	102.8
Gun Directors	100.

What Is Radar's Future?

SINCE V-J Day, the question has often been asked: How will radar serve the arts of peace, and what contribution can the Western make to its advance?

Numerous applications already have been suggested for radar in the field of transporation. Airliners need no longer bow to the whims of weather, and weather prophets can probe the skies for hidden storms which heretofore have threatened shipping. Radar can lead vessels into fog-bound harbors and point out the many hazards which menace navigation. Had the ill-fated Titanic of a generation ago carried radar search gear, she could easily have found safe passage through the ice fields of the North Atlantic.

Of still greater value may be the indirect applications of radar's technology. The Bell System recently demonstrated a multi-channel system of radio telephony which promises great economies in extending telephone service to areas now isolated by water or difficult terrain. The circuit re-arrangements and electronic components of the new system are greatly indebted to radar. The new Bell Laboratories development for making speech visible to the deaf employs components closely related to some of those in radar. Television, electronic calculators, automatic warning devices . . . the list of possibilities seems endless.

But whatever usefulness the future may contrive for radar, none will eclipse the attainments of its recent past. With radar, our fighting men emerged triumphant. How much dearer might the cost of victory have been without the help of radar?

THE MEN AND WOMEN of the Bell System, through whose toil and skill the miracle of radar was so largely wrought, may—and do—have a proper sense of pride in the true worth of their accomplishment. They face the future with long experience now enriched by the lessons of a new technology. Just as radar has already begun to plumb the vast expanses of inter-stellar space, so will these men and women continue their explorations in the limitless realm of science and from their findings build a greater telephone system for the greater America of tomorrow.

Panic on the Telephone

AFTER three long years in the African and Italian campaigns, Doctor Joe was on his way home. When his wife, Myra, heard the exciting news, she began planning just what she would say when that first precious telephone call came through after the ship docked. The call had to be perfect. But the more she tried to tailor some appropriate remarks to fit the little wedge of talking time, the more panicky she became.

Finally, in desperation, she appealed to her cousin, a young lieutenant just back from overseas. Would he phone her a few times and help her rehearse?

The lieutenant laughed at her. "Why there's nothing to it," he said. "Look. When the call comes through, you'll say, 'Hello darling,' and Doc'll say, 'Hello, darling, how are the children?' And you'll tell him they're fine, and then the talk will go zooming on from there. It's a cinch."

Two nights later, the New York operator asked Myra if she would accept charges on a call from Doctor Joe. After a long, tense wait, there was his voice.

"Hel-LO, darling!" Myra caroled.

"Hel-LO, darling!" boomed back the doctor.

Then he got stuck, she got stuck. Silence. Panic-stricken, Myra wildly recalled the lieutenant's formula. Into the phone, she shouted, "Darling, how are the children?"

And Pappy Joe, who had been away three years, yelled dizzily, "Oh, fine! Just fine!"

—MARJORIE STOLL.

Reproduced by permission of the Saturday Evening Post. *Copyright 1946, The Curtis Publishing Company.*

Getting Telephone Service Quickly to the Many Who Have Waited a Long Time for It Is the Bell System's Biggest Emergency Restoration Task

The Bell System's First Order of Business

Harold S. Osborne

MORE THAN 2,200,000 telephones were connected by the Bell operating companies in the five months starting last October. That is by far the biggest number ever installed by the System in a comparable period.

And the trend is upward. Connections in December were 440,000. In January they were 487,000. The February figure was 491,000.

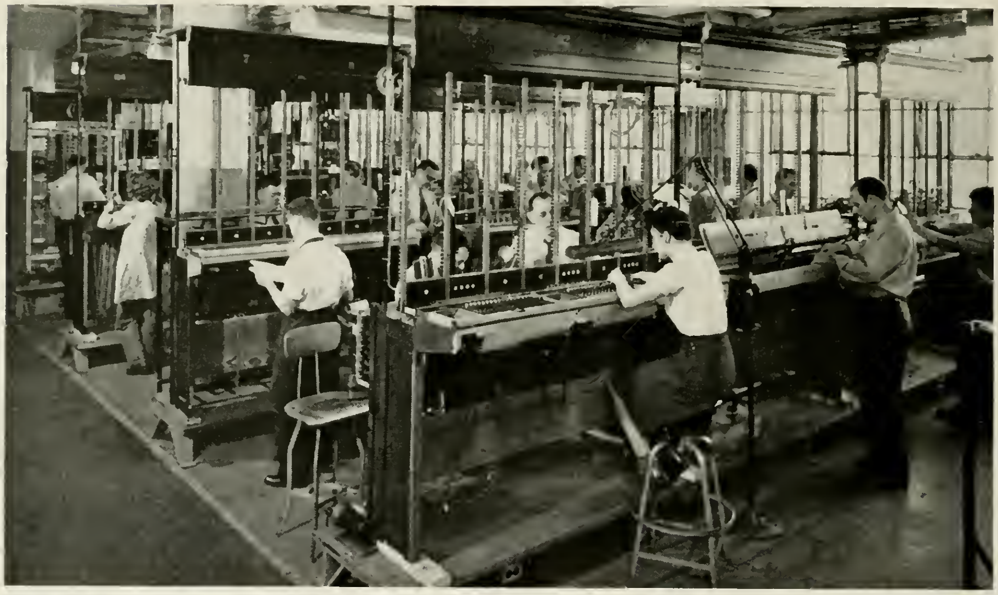
Net telephone gain—the balance after disconnections are subtracted from connections—is the highest in history. In that five-month period it was 1,140,000. Currently it is running at the rate of 3,600,000 a year.

These figures are evidence of tremendous accomplishment. They demonstrate the pace being set by the Bell System in its drive to give telephone service to waiting customers whose orders have been unfilled because of wartime shortages of facilities.

Coupled with the day-to-day tasks of providing and improving the nation's telephone service, this emergency program is the Bell System's first order of business. It will continue to be so until the last waiting customer has been served and telephones for everyone are once again being installed promptly on request.

Providing telephone service for all who want it, when they want it, and the way they want it is the normal responsibility of the Bell System. The System had met this obligation fully and pridefully until the telephone went to war. But in the years when victory was the first order of business, and telephone materials and equipment were needed by the Armed Forces, a huge backlog of unfilled orders piled up. With V-J Day, Bell people everywhere swung into an emergency program to clear these held orders with all possible speed.

And it is a real emergency—the greatest in Bell System history—more



In many a Western Electric distributing house, old switchboard sections, removed from manual offices after dial conversion, are being reconditioned to go back into service in other manual offices to help relieve the equipment shortage

---

extensive than any ever caused by flood, fire, wind, or sleet. It's nationwide. It's fundamental. It's intricate, complicated, and tough to overcome.

The peak in held applications for main telephone service, 2,170,000, was reached last September. At that time more than 900,000 were "held initially for instruments" and the balance of more than 1,200,000 for the lack of central office equipment and outside plant.

Since then, the volume of new orders has broken all records. On top of all those held orders, nearly 2,000,000 *new* applications for main telephones have been received in those five months—almost half of them in the first two months of this year—and there is no let-up today. Many of these new orders have been filled for customers who qualify for preferred treatment under the order of precedence established by the Government. Others have, of necessity, been added to the waiting list.

Concurrently, service has also been provided to a substantial proportion of the customers who have been waiting a long time. But because of the new orders received since the war, the total waiting list is still very large—more than 1,900,000 on March 1.

As more and more telephones are installed, the margins for growth which have existed in many central offices and cables have been used up. This in turn has brought about a substantial increase in the the number of customers who, although qualifying for preferred treatment under Government regulations, have to wait for service because of lack of facilities.

Their applications now constitute more than ten percent of all held orders. And such applications must be filled ahead of those from customers who do not qualify for preferential treatment under the regulations.

The manufacture and installation of hundreds of millions of dollars' worth of telephone plant to fill hundreds of thousands of orders for telephone service is not an over-night process. The time factor in many cases is not weeks but months.

That's the situation the Bell System is fighting today with every weapon in its peacetime arsenal.

Western Electric Turns to Peace

After V-J Day, the Western Electric Company moved in record time from large-scale production for the Army and Navy to large-scale production for the System telephone companies.*

Western is now turning out telephones at the highest rate in its history: 14,000 a day.

It is now producing dial central office equipment at maximum pre-war capacity—1,000,000 lines a year—

---

* See "Western Electric Tackles The Peacetime Emergency," Magazine, Autumn, 1945.

In many places there is a neck-and-neck race between facilities and service. Here an operator is handling calls at a position for which the multiple is only partially completed, while installers are working on still another switchboard section

This business has lived and grown successful and of good repute by giving service.

It has given the public what it wanted when it wanted it, and done it with efficiency and courtesy—and then invented better things and taught the public to want them and ask for them.

That is what made this business something more than just a business.

It made it a good place to work, a good life to live, something with a little distinction.

It did its best to serve the public.

That paid off when it was comparatively easy to do.

Well, now it is hard—what about it?

What do we do?

Shall we run the business for our convenience?

Shall we run it to meet some long distance "prove in" rules?

Shall we serve our engineering studies?

Or shall we serve the public?

What is the objective?

To give people the best possible service as cheaply as we could do it.

But the "service" comes before the "cheap."

And not just to serve those we found it convenient to serve.

Our job is to serve every single person that we possibly can, and get service to them as fast as we can.

That may mean putting plant in and taking it out again in a little while.

What did we do after the hurricane?

Did we wait until we had everything engineered for 1960?

We did not.

We got something going fast and improved it afterward.

and expects to step up this rate until it reaches 2,000,000 lines this year.

It expects to ship at least 1,400,000 lines of dial apparatus in 1946.

Cable, wire, and other items essential to telephone service are being produced at pre-war levels or better, and production is still rising.

Western Electric also is obtaining telephone equipment from other suppliers and from Government surplus. Facilities no longer required in military establishments and war plants are being recovered for civilian uses.

Through the Western, the Bell System was successful in bidding-in the first lot of surplus telephone equipment which was sold by the Reconstruction Finance Corporation. This consisted principally of some 15,000 standard Western Electric combined telephone sets and a quantity of standard lead-covered cable. The System's purchases of surplus equipment have totaled nearly $2,000,000 to the first of March.

With the coöperation of the Armed Forces, more than 138,000 Bell-owned telephones no longer needed in government-owned ordnance plants and military esablishments were removed between June and December. About 1,000 Bell-owned manual and dial P.B.X. switchboard positions were similarly recovered in the same period. The Associated Companies also are purchasing small lots of war surplus materials directly from the Signal Corps when usable items become available in their territories.

All of this material has been or is being rushed back into service for civilian users.

Western Electric's Hawthorne Works had some 600 equipment engineers at work on the lay-out of new dial central office equipment for the Companies at war's end. Now it has 500 more—and the group is still growing. The engineers are working six days and two evenings each week.

So the Companies are going to engineer small step-by-step dial central office additions themselves, just as they do small manual jobs.

On larger dial installation jobs the telephone companies are working out other ways to lend Western a helping hand. Some companies find it feasible to send their own equipment engineers to Hawthorne to engineer certain jobs. One company thus saved the Western's engineering force 135 man-weeks of work.

Special off-the-job class-room instruction to supplement the training of Western Electric employees who install central office equipment began immediately after V-J Day. By the end of the year more than 3,000 men in 40 cities had had this supplementary training—and this program is constantly being stepped up.

In March of this year there were more than 10,000 on the Western Electric equipment installation force, an increase of some 6,000 since Japan surrendered. By the end of the year this force will be built up to 22,000, and will require about as many supervisors as there were installers on the payroll in the middle of 1944.

Well, this is just like the hurricane, but a whole lot worse.

What did we expect—to have the worst war in history and have it result in the millenium of ease and comfort?

The phrase "the war is over" is an hallucination as far as we are concerned.

The war has just got to our front.

This is our big time, and if we are not going to throw away all the ideals of our history we are going to take off our coats and show the world what we can do in a fight.

Are we going to degrade service a bit for the many to give service to a few more?

Sure we are.

We are going to give everyone some service just as fast as it can be done, and we are going to tell everyone exactly what we are doing.

This is no time for little faith, or half-way measures.

It is time to strain every effort to give service, and a time for full explanation of what the facts are.

Take a vote.

Ask the public, do you want telephones now or a little saving later and a perfect engineering record?

Maybe we don't face those questions in those words.

But we do face those questions.

And I have no doubt what the answers are.

The question is how good a job do we do.

How much of lasting satisfaction do we get out of recognizing the biggest and hardest job we ever had, and licking it.

From a statement, "What We Think about Held Orders," by Arthur W. Page, A. T. & T. vice president in charge of the Information Department.

THE WHOLE emergency program is geared for high speed. High-speed restoration work uses up extra money the way high-speed driving uses up extra gas. But telephone people have a goal to reach in a hurry. They figure the money cost is cheap in comparison with the value of being able to give service as promptly as possible to everyone who wants it and needs it.

War Experience Proves Helpful

THIS BUSINESS operates through tried and tested methods and practices, developed and perfected through the years. But it recognizes also that unusual circumstances sometimes demand unusual actions.

During the war, the Bell System added three million telephones, needed for the war effort, with relatively little additional plant. It reconditioned and installed nearly a million old telephones which normally would have been junked. It made other telephones out of parts which were made available, and converted telephones from one type to another to meet special needs. It increased the load on central office equipment by five and ten and even 15 percent above that for which it was designed with ordinary standards of service. It devised ways to utilize the local cable plant more completely.

The experience gained during the war in the use of expedients and the application of ingenuity is standing the System in good stead now.

Old type telephones have been reconditioned, for example; surplus coin telephones have been converted to wall sets; and manual desk stands have been converted to dial.

AN experienced telephone man instructs two high school boys in the fine points of installation, which they will be able to apply on customers' premises during their out-of-school hours

ADVANCE WIRING of subscribers' homes gets everything ready to connect telephones just as soon as they become available. Here a customer and his small daughter watch the process approvingly

One company devised a combined set, for use where the bell boxes could not be fastened to walls, by mounting a hang-up set and bell box back-to-back on a wooden base.

Another company, needing magneto wall sets to furnish service in rural areas, sought out and purchased more than 2,000 from farmers. They had been discarded when farmers' service-station lines were cut over to community dial operation several years before. It didn't take long to recondition and put them back in service.

Telephones Were the First Need

AS OF THE END of last September, 900,000 applications for telephone service were held solely for lack of telephones, in locations where central office and cable facilities were available. Between then and March 1, Western Electric—thanks to its remarkable reconversion job—has shipped to the Bell operating companies more than 1,200,000 telephones.

At the same time, those companies have been building up their installation forces to put those telephones into service for people who have been so eagerly awaiting them. During 1945, 15,600 employees who had been on leave of absence to serve with the Armed Forces were welcomed back, and more than 10,500 veterans of World War II who had not previously worked for the Bell System were hired. This happy process is continuing.

Newcomers to the business are teamed with experienced employees and sent out on the job, to "do while learning" as well as to "learn while doing" so as to get on with the work as rapidly as possible. In many instances, employees who formerly were installers have been transferred to that work temporarily from other less pressing assignments.

Several companies have been using groups of less experienced installers to "pre-wire" premises of applicants who were scheduled to get new telephones as soon as a shipment of them was received from Western Electric or when additions to the equipment in central offices were about completed. Usually "pre-wiring" includes all of of the work required on a customer's premises except the installation of a telephone set.

At least one company used such a group as a flying squadron to install telephones anywhere in its territory. There are 60 members of this group, almost all of them new telephone men recently released from the Armed Forces. They are made up into five squads, ready to go to work installing service for those on the waiting list the minute the equipment situation makes it productive for them to move into an area.

In another area, high school boys have been trained in certain installation procedures, and are sent out in taxicabs during their free hours to help pre-wire customers' premises.

MEMBERS OF A specially organized "flying squadron" of installers receive instructions before moving into an area where equipment is now available to serve those on the waiting list

By such expedients as these, as well as by the more usual methods, the Associated Companies have built up the rate of installation to keep pace with Western Electric's production of telephones. Applications "held initially for lack of telephones only" have been practically eliminated; the System companies are receiving telephones for installation in substantial and increasing numbers; and this important part of the whole problem is well in hand.

Central Office Equipment Too

As of early Spring, at least 80 percent of all held applications for service are unfilled because of the lack of central-office equipment. That makes this the most important factor of the whole emergency program, and gives ingenuity the opportunity to work overtime in an effort to give service to more customers—sooner.

With so many offices loaded to the gunwales, any office which has a small margin of equipment over the immediate demand for service provides a challenge to the engineer. He has found several ways for capitalizing on it. In a large city it may be possible to transfer customers in a boundary area to the less congested office, or to connect customers from one office area into another one by utilizing spare trunk conductors or placing new trunk cables. In many cases equipment has been taken out of one office and re-installed in another where it is more urgently needed.

Is one office short on line circuit terminations? Then increase the telephones on the party lines until every line is handling its full quota of parties, even if the pairs serving parties have to be connected together in the central office itself.

Station wagons have been adapted to serve as installers' trucks

Perhaps the dial operators' positions can handle a little more traffic. In that case, lines can be connected for manual originating service, while calls to those subscribers will be completed through the dial equipment.

Most offices are short on terminal numbers. How can every number work all the time? Assign a new customer to any disconnected number as soon as it is released. The new subscriber will get some calls intended for the old one. But that's much better than no service at all.

At the same time, the terminals used for testing purposes are being cut to the barest minimum, and the same is done with the numbers used for company business.

Means have been devised for making a single dial number terminal do double duty, serving to reach two customers on the same party line.

As new equipment is produced, the use of every frame and switch is planned with the utmost care. Ways have been found to drop out 15 percent of the equipment in new crossbar offices temporarily by cutting corners and eliminating every frame not immediately essential to service. The provision of equipment for growth in service after cutover has been reduced to the bare minimum needed to carry on until the next addition can be

THROUGH an ingenious re-arrangement, this bank of step-by-step dial central office switches is temporarily serving twice as many subscribers as it was designed to take care of

Has a block of numbers been assigned for coin box growth? Cut it to the minimum and use the numbers thus released for regular service. Likewise, go ahead and use numbers that have been saved for growth in business P.B.X. groups.

rushed in. A few frames here, a few switches there, may not sound large; but if you can defer them and still give service in a hundred jobs, it means that perhaps ten new jobs, otherwise impossible, can be squeezed in.

Typical ground rules for the engineer are:

Since party service can get by with less equipment than individual, plan for party.

If you can possibly do without a test frame, leave it out.

If you can use a small manual position in place of a large one, do it.

Installing new central office equipment takes time. There are thousands of wires to place and solder. The quicker it can be done, the sooner service can be given; and new installation schedules have been worked out to use maximum manpower and double shifts, thereby shortening the time the installation requires from 15 to as much as 30 percent.

Just as customers' premises may be pre-wired, so cable racks and cable may be placed in advance, in order that as soon as the factory can get the equipment on the job, wires will be waiting to be soldered to it.

Distributing frame jumpers are laid in place ready to solder.

Test procedures that intervene between the completion of an installation and the connection of new service are cut to a minimum.

There must be no lag; when the equipment is ready, service will start.

Buildings Are Needed

In scores of localities throughout the System, either new buildings or substantial additions to present structures must be erected before additional central office equipment can be installed.

Erecting a building today is a tough job. It takes something more than know-how. It takes *determination.* One has to make up his mind he's *going* to build it, come hell or high water. Then he has to imbue the architects and contractors with the same spirit.

The companies are tackling the job that way, and it works. They have also found they had to reverse many usual procedures. Instead of drawing plans and then buying materials, they have sometimes had to buy what materials were available and then modify the plans to fit them.

If bricks for additions don't match those of original structures, what of it? A vine can be planted or a rain spout located to cover the break where the color changes. If doors and windows don't quite match those in the original structure, who cares—just so they open and shut? If only cinder blocks are available, O.K., cinder blocks are used for inner walls and the exterior faced temporarily until bricks can be had.

Never mind if the plans aren't finished, go ahead and dig the basement. Equipment on hand before the building is finished? Then knock up temporary siding, and start the installation as soon as the inside is finished and the outside is weather-tight. Days too short to meet the completion date? Rig up flood lights and work nights.

That's the way the Bell System builds buildings in this emergency. Costly? Of course! But effective.

Making Every Cable Pair Count

Outside plant, too, is getting the same emergency treatment. Nothing new is added unless and until all existing facilities are "full-up." When they are, short cables often are placed to transfer pairs from full feeder cables to others in which there are spares.

Government surplus cables purchased by the Western through the R.F.C. are used where they can be made to serve—even in unorthodox ways. If it's the only kind available, cable designed for submarine installation may be placed underground; cable made to be buried may be strung aerially in place of plain lead cable; two 11-pair cables are strung together instead of a single 26-pair cable; quadded toll cables are introduced into exchange plant.

Cable troubles are cleared when they occur. Normally, spare pairs are provided for growth and for maintenance. It is often more economical to maintain service by merely transferring to a good pair when one goes bad. Now the need is for more working pairs in existing cables, so every effort is made to keep all pairs working.

All cable-placing projects not incidental to or part of the emergency job are postponed "for the duration."

Tools and Vehicles Needed

All sorts of ways are being found to augment war-depleted vehicle fleets. Companies have purchased second-hand trucks and passenger cars, and have rented their personal cars from employees and construction trucks from other utilities.

Some of the companies have recently received a few new truck chassis. Since bodies weren't available, they built stake bodies and mounted pole derricks and winches on construction-truck chassis, and bolted pick-up bodies on installation-truck frames.

In order to make one motor vehicle do the work of several, half a dozen men are often assigned to an installation truck. These men work in a limited area and the truck keeps them supplied and moves them from job to job.

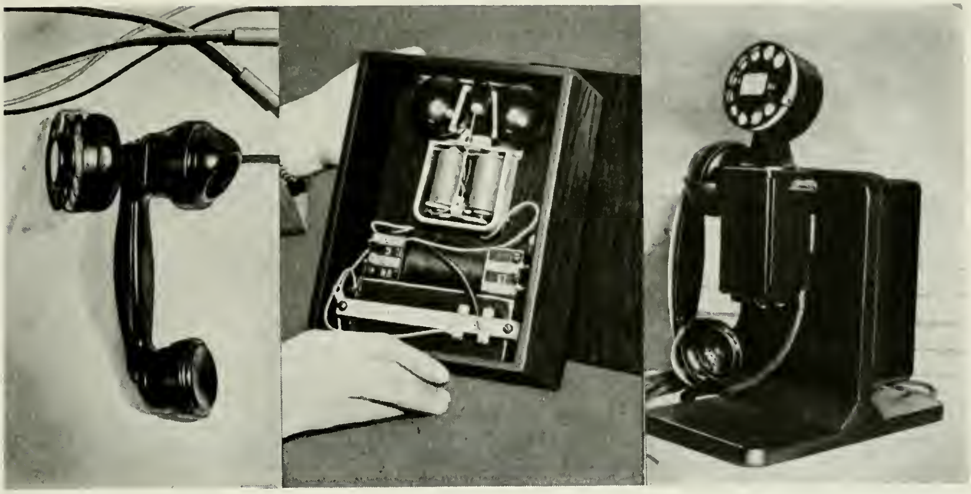
Outfitting the fast growing installation forces with hand tools and test sets has also taken a bit of doing. Every possible source of tool supply has been tapped, including local hardware stores, auto accessory shops, and mail order branch stores. Local supply people, working closely with Western Electric buyers, have made local purchases of thousands of such items as pliers, screwdrivers, hammers, bits, braces, star drills, axes, and hand saws.

Installers' tool bags have been on the shortage list. Since leather is scarce, heavy canvas bags are being substituted. One company found it could get plenty of canvas bags made up by an awning manufacturer while his business was suffering its usual mid-winter slump.

"Make-do" dial test sets are being produced by Western Electric distributing houses. These are being assembled out of old handset handles, dials, and other standard parts produced for other uses. One house turned out five hundred for use until the standard rubber encased type is available.

And that isn't all. Here and there throughout the System the companies have been:

Taping worn or frayed telephone cords, so that most of the production



While the shortage of telephone instruments was acute, some make-do models were put together which can't be found in any catalog. Left to right, above, are, a dial test set, a wooden box for the subscriber set, and a back-to-back arrangement of a hang-up telephone and a wall bell box

of new cords can be used to equip new telephone sets;

Recovering protectors as well as instruments when telephones are disconnected, to alleviate the shortage in this item of equipment;

Using home-made connector blocks and ground rods to overcome temporary shortages;

And saving, reconditioning, and reusing everything with any life left in it.

All Departments Speed the Job

The drive to get service to waiting customers in the shortest possible time affects most directly, of course, the Plant and Engineering Departments and Western Electric. But all departments are making important contributions to the effectiveness of the job.

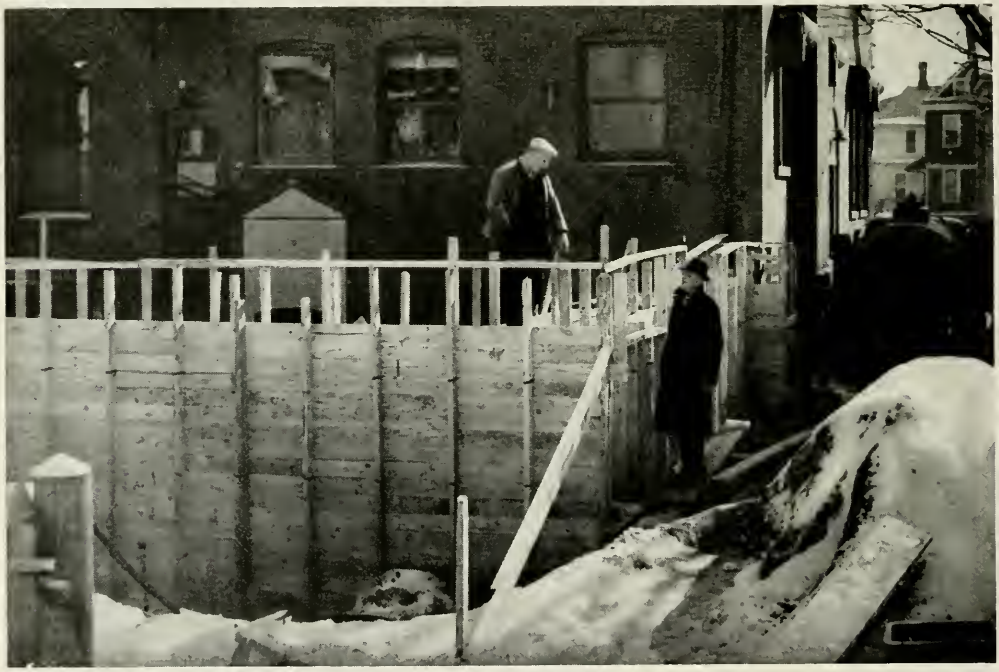
The business offices, which have custody of the held-application files, are also custodians, in a sense, of the System's good repute among all who want service and have been unable to get it. For it is here that detailed records of service applications are maintained and it is the business office people who must keep those files up to the minute, must answer the anxious and sometimes skeptical inquiries of waiting applicants, and must, as facilities become available, make sure that the applications are filled strictly in their proper turn.

Now that facilities are becoming available in larger quantity, special arrangements have been worked out for issuing service orders so that the Plant Department can put into use without delay the facilities to provide service to applicants whose turn has been reached. But before an order can be issued for the installation of any telephone, a check has to be made with the applicant to make sure he lives at the address given and still wants service. At present, more than 70 percent of the applicants on the waiting lists still want service when it becomes available to them.

This checking frequently is handled by special groups of new employees who have received short specialized training courses in this phase of the job. This helps to relieve the work load on the more experienced representatives, who are busy handling the unprecedented volume of applications for and inquiries about service.

The directory people, too, have had to find ways of keeping up with a greatly increased volume of work without sacrificing any of the accuracy which is so essential in compiling directories both for public use and for the use of the information operators.

Traffic people are seeking and finding ways to speed the job. The desire to provide service for everyone has become an important part of the fundamental objective of giving the "best possible service". Traffic engineers and general engineering people are increasing their usual close relationship. One department in effect "looks over the shoulder" of the other at work in progress, so that ideas can be exchanged and modified without waiting for completion of plans to

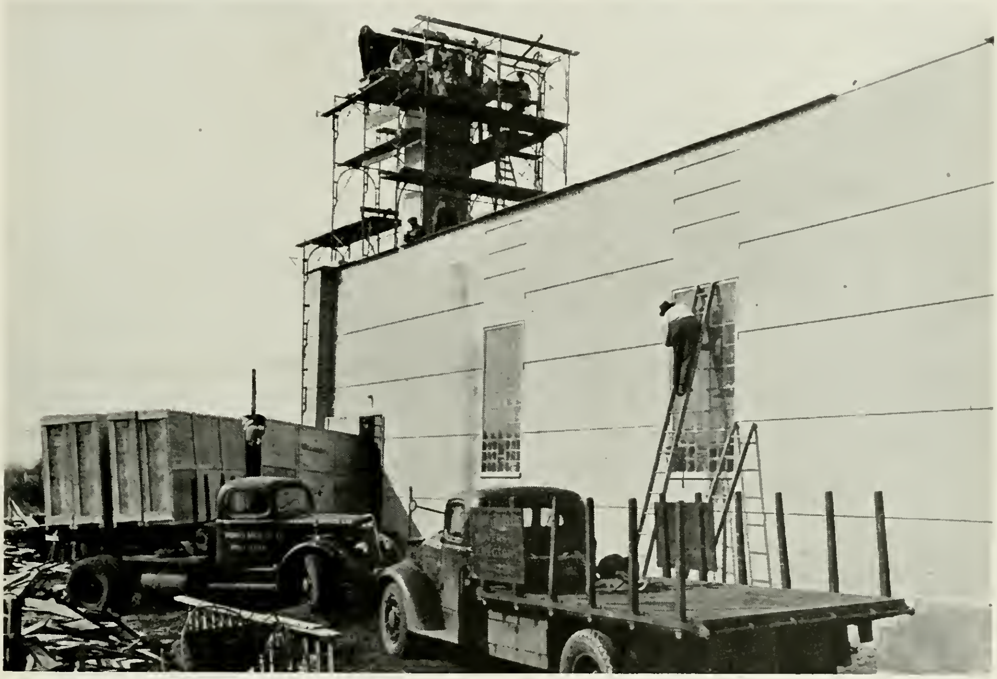


THERE'S NO WAITING for Spring weather here. Work on an addition to this telephone building progresses in spite of winter storms and low temperatures the last detail. Frequently, they find it possible to postpone certain time-consuming details for later action in order to get on with the job.

Continued emphasis is being placed on recruiting new operators, and it is expected that the System's operating force will be increased by 60,000 during 1946—more than twice the increase in any previous year. Special training positions, ordinarily a part of the regular switchboards, are being provided to permit full scale training away from the switchboard, thus making possible the full use of existing facilities for service to a constantly increasing number of customers.

All these efforts to get service to many people quickly increase the volume of work in the Accounting Departments, which keep the records of customers' accounts and prepare all monthly statements. Accuracy and speed are essential in this work, which for efficiency is organized on a production-line basis calling for coördination and teamwork at every step.

To keep pace with the huge volume of new accounts, it is necessary to carry on a continuing program of recruiting and training new sorting clerks, rate clerks, toll billing typists, toll ticket sorting clerks, and other important personnel in the intricate organization which is Accounting.



NEW DIAL equipment is unloaded for installation while work on the exterior of the building is being completed

These new people must be assigned to productive jobs as rapidly as possible but without impairing the operating efficiency of the offices.

Reporting on Our Progress

BELL SYSTEM workers are busy—too busy to stop and talk much about their accomplishments. But the people of America are entitled to know how they're getting along.

When you add to the numbers of people still on our waiting lists all the members of their families and all the friends who want to be in telephone contact with them, you've got a sizeable segment of America's total population.

So the telephone companies are reporting on their progress, in newspaper advertisements and articles, magazine advertisements, on the radio, in letters and pamphlets, window displays, posters, bill inserts, public talks, and other ways.

Employees are kept informed so that they can answer queries correctly. Also, it's just good sense to answer the question: "How're we doin'?"

The companies are answering that in bulletins, in their magazines, in booklets, at employee meetings, on posters, pay check inserts, and in similar ways.

The unprecedented situation of very many customers waiting for a telephone service which can't be given them immediately presents a challenge to the Bell System. Rising to that challenge, telephone men and women everywhere voice a resounding second to the pledge made last Spring by Walter S. Gifford, president of the American Telephone and Telegraph Company:

"We pledge the American public that after the war or as soon as materials and supplies become available again, we shall do everything in our power to speed the day when all who want telephone service can get it and, what is more, can get the type of service they want and as much of it as they want."

"SERVICE TO THE NATION IN PEACE AND WAR" is the tradition, the constant purpose and the daily work of the Bell System. From Pearl Harbor to V-J Day, the System met the continuously increasing war communications needs of our country, and its experience in overcoming war difficulties gives further assurance that it will meet the needs and opportunities of peace. Today and tomorrow its welcome task is to make telephone service better than ever before and increasingly useful to more people. . . .

Today, in the aftermath of war, the nation is exploring its resources and working toward a new equilibrium. The problems of human and physical readjustment have closely affected the Bell System as they have all business. These problems demand—and they are getting—the utmost effort in order to insure the rendering of good telephone service all the time. The management of your Company was never more mindful of its duty to meet its public service obligation fully and to see that the message gets through. It looks forward to providing more service and better service, more jobs and better jobs, than ever before.

From the A. T. & T. Annual Report for 1945.

Consolidation of Keystone System with Bell Company of Pennsylvania Eliminates an Uneconomic and Inefficient Situation in Only Big City Where It Had Continued

Dual Telephone Service Ends in Philadelphia

Peter L. Schauble

In Philadelphia, third city in the land, 43 years of duplicative telephone service came to an end early one Autumn morning of 1945.

At 7 A. M. on Monday, September 17, fuses were pulled in the central offices of the former Keystone Telephone Company, cutting off the power supply and silencing the Keystone telephone system, while at the same moment circuits were closed in several central offices of the Bell Telephone Company of Pennsylvania to provide new or additional Bell service to former Keystone subscribers.

Philadelphia had been in recent years the only large city in the country in which two telephone systems have rendered service side by side. The events of that September Monday morning, bringing to a climax long months of preparation, construction, and installation, thus marked the ending of an epoch.

Starting service in 1902, the Keystone Telephone Company's operations were centered in Philadelphia. It operated approximately 45,000 telephones and seven dial central offices in that city, and a few hundred telephones in suburban territory in the Pennsylvania counties surrounding Philadelphia. Through associated companies—the Eastern Telephone and Telegraph Company and the Camden and Atlantic Telephone Company—it also operated about 5,000 telephones in southern New Jersey.

In Philadelphia, Keystone service was concentrated in the business districts. Its slogan long had been, "When the Keystone Rings, It's Business," and it actually served fewer than 500 residence subscribers.

The company had had practically no main station growth in the last 20 years of its existence. It had never paid any dividends on its common stock, and it was in arrears on dividends on its preference stock by about ten times the designated annual payments.

More than 93 percent of the 13,000 Keystone subscribers also had Bell service. The Bell Company, at the time it acquired the physical properties of the Keystone company, operated approximately 465,000 stations in Philadelphia.

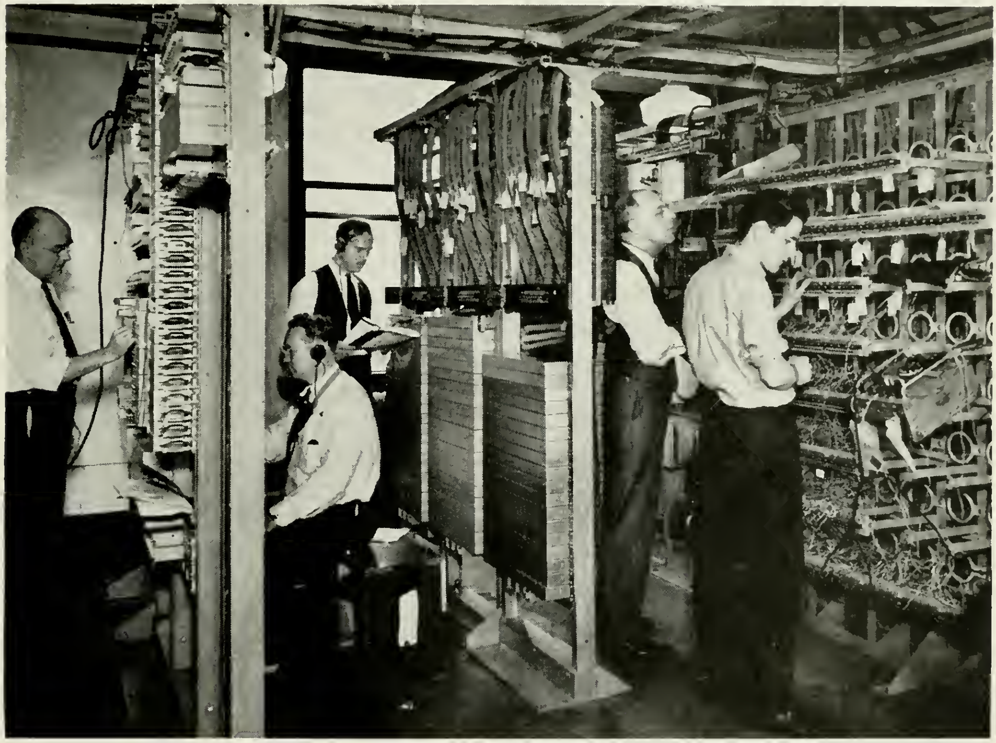
Preliminary Steps

THE FIRST STEP in the purchase of the Keystone system was an agreement between New Jersey Bell Telephone Company and the Gary interests for the purchase by the New Jersey Company of the stock of Imperial Securities Company, a holding company which controlled the three Keystone operating companies. On January 30, 1941, the New Jersey Company filed an application with the Federal Communications Commission asking its approval of the purchase of this stock. An amended petition was filed on July 23, 1942, in which the Bell of Pennsylvania joined, asking that approval also be

"LET 'ER GO!" Connected by telephone with all the central offices involved, Carl R. Freehafer (left), vice president and general manager, Eastern Area, Bell Telephone Company of Pennsylvania, gives the order which consolidates Bell and Keystone service in Philadelphia given to the purchase of the physical properties of the Keystone system by the two Bell companies.

The FCC held seventeen days of hearings in 1941 and 1942 and took 1,449 pages of testimony. It approved the proposed purchase in March, 1943, stating that consolidation "will be of advantage to the persons to whom service is to be rendered and in the public interest."

"Users within the competitive areas are inconvenienced by the necessity of having two telephones in order to obtain comprehensive service, and in selecting between such telephones in calling other persons who subscribe to only one of the services," the FCC order stated. "This dual service involves duplication of line and line structures, central offices, and telephones and duplication of costs for maintaining and operating separate facilities whose function could be served by a unified plant.



WESTERN ELECTRIC installers at work on the frames of a new dial private branch exchange system being installed in a large Philadelphia bank to replace a combination of Bell manual service and a private dial system which connected with Keystone

"We find . . . that disadvantages to particular users which may result from this program of acquisition and consolidation proposed by applicants are outweighed by the benefits to the

Fifty-two hundred service orders were written in Pennsylvania as a part of the consolidation program. Here, one of them is going by teletypewriter to the test center involved

general public to be served and the advantages of increased efficiency, convenience and comprehensiveness of service which may be expected to follow. . . ."

The Commission also pointed out that the conservation of materials essential to the war effort was another important factor. It was estimated that about 1500 tons of copper and smaller quantities of other critical metals would be released by the unification.

Following approval by the FCC, the New Jersey Bell Company acquired all the stock of Imperial Securities. F. F. Addicks, general plant manager of New Jersey Bell, became president of the Keystone Telephone Company of Philadelphia, and a number of the new directors and officers were Jersey Bell officials.

A meeting of the Keystone stockholders was held on June 22, 1943, to approve the sale of the physical properties to the Bell companies, to give up the company's telegraph rights—a necessary step under Pennsylvania law—and to dissolve the company after the sale of its physical properties was consummated.

Subsequently, applications were made to the regulatory bodies of the two States involved. In Pennsylvania, the Public Utility Commission held two hearings—at which comparatively few objections to the proposed consolidation were raised. It was testified at the hearings that while increased telephone costs would result for some few Keystone users after the consolidation, the majority would save on their telephone bills. It was estimated that the net annual over-all decrease in costs for users of Keystone service would be in excess of $100,000.

Both Commissions approved the project, the Pennsylvania Commission stating that the merger would benefit both Bell and Keystone subscribers and that it would be of long-range benefit to the public.

Special Organization Set Up

After legal details of the sale were completed, the Bell companies took over the physical properties of the Keystone system in the Fall of 1944. At that time Keystone had 394 employees in Pennsylvania—66 of them in the armed forces—who were taken into the Bell of Pennsylvania organization with full credit for the length of their Keystone service in benefits, pensions, and similar matters.

Preparations were begun immediately for consolidation of the two systems. Keystone telephones in Pennsylvania, meanwhile, were operated as the Keystone Division of the Bell Company.

A consolidation committee, made up of personnel from the departments involved, prepared plans for the consolidation and cut-over. This was supplemented by a cut-over committee, in charge of the execution of plans.

Engineering groups studied the available types of Keystone equipment, to determine which could and which could not be used for Bell service. These studies resulted in the retention of Keystone handsets, some special switchboards, and a certain amount of other equipment. The general plant supervisor's forces developed maintenance practices for this equipment, and training of maintenance personnel was done by Bell field forces.

The sales organization began the task of interviewing the approximately 13,000 Keystone subscribers, making surveys of the equipment in service, the subscribers' telephone needs and usages, and arranging for the issuance of service orders in connection with the necessary installation of additional Bell equipment and rearrangements of existing equipment.

TO PROVIDE sufficient Bell service to take care of the expected demand meant that additional equipment had to be installed in various Bell central offices. Because of Keystone's concentration on business service, it was found that the greatest additions would be needed in the Lombard central office, located in the center of the city, and the Regent central office, in the industrial northeast section.

At Lombard, where the largest installations were made, it was necessary to add two sender frames, two link frames, four district frames, two line finders, and one office frame; and 1,200 subscriber lines, 213 final selectors, and 190 dial impulse repeaters. In all, seven Bell offices required additional central office facilities, and a large number of outside plant rearrangements and additions were necessary. A total of 1,134 work orders to construction forces were issued for outside plant work.

All of the large Keystone subscribers had duplicate service. This meant that in some cases, where Keystone usage was light, only very slight additions to subscribers' facili-

CUTTING OFF the life blood of the Keystone Telephone System: Mr. J. W. Root, retired, Keystone's oldest employee, pulls the fuses at Keystone's Race central office ties had to be made to the Bell installations already in place. But in many instances this was not true, and neither the Bell nor Keystone installations were large enough to handle the combined traffic expected after the consolidation.

In some instances, new Western Electric facilities were available for replacements. But in a number of cases these problems were solved by a complicated exchanging of equipment, so that a Bell or Keystone switchboard removed from the premises of one customer was reconditioned and installed for another customer, while the first customer might receive equipment formerly used by still a third subscriber.

As an example, before the consolidation one large subscriber used a 6-position manual Bell switchboard, serving 483 telephones, and a subscriber-owned one-position dial PBX connecting with Keystone lines and serving 623 telephones. The subscriber-owned Keystone telephones were used very largely for interior service. In unifying the service, subscriber-owned facilities were purchased and a new 4-position Bell dial PBX was installed, with 629 telephones. In this case, new Western Electric PBX facilities were available, and the older equipment was removed, modified, and re-used for other subscribers.

Another complicating factor was the large number of so-called "trader boards" operated by Keystone, and used by more than 100 large subscribers, most of them financial houses. This was a special development using large amounts of lamp and key equipment and private lines. Some of these "trader boards" used as many as 60 lines, connecting both with the central office and with perhaps 25 other subscribers over private lines, and having as many as ten operating positions. An intricate network of private lines was thus involved. These arrangements were taken over virtually intact. The former Keystone service was, of course, confined to Philadelphia and nearby subscribers; but after the cut-over it was possible to add several leased lines to New York and other outside points for some of the "trader board" users.

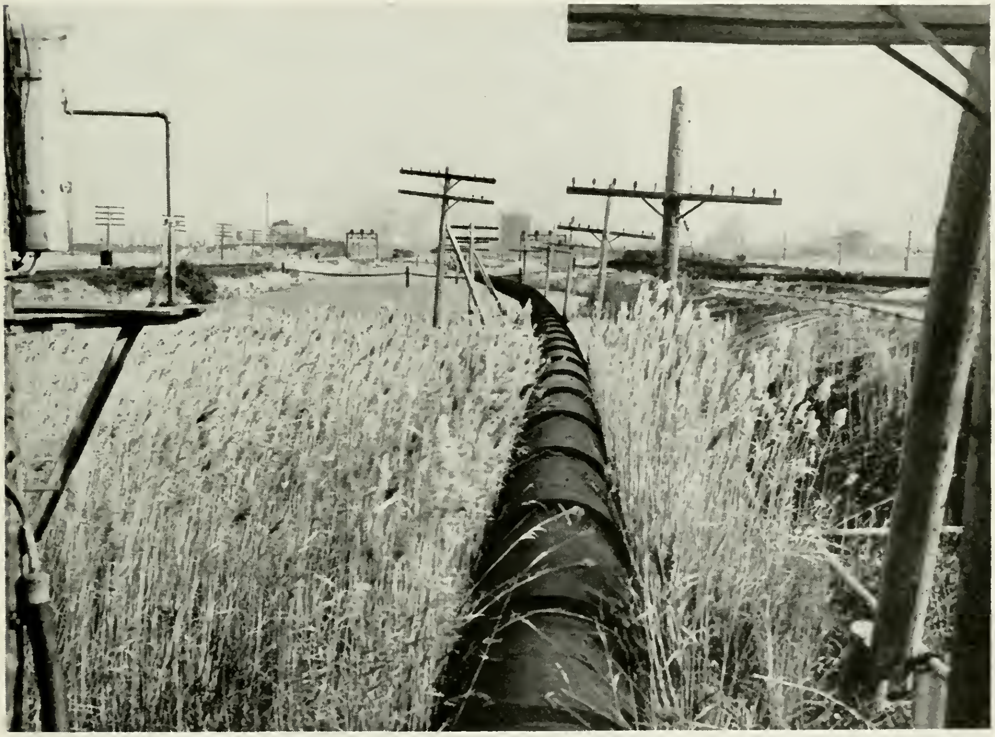
The large number of leased lines provided by Keystone to telegraph companies, fire and burglar alarm systems, and wired music firms also meant extensive rearrangements of plant. Keystone had approximately 3,500 such lines. It was necessary to make entirely new circuit arrangements in most of these cases, so that the services provided by the two systems could be coördinated into one without interruption to service.

Easing the way toward the final consolidation was an agreement with many large subscribers, prior to consolidation, that as soon as additional Bell facilities were installed their Keystone service could be discontinued. Practically all of the large PBX users who required new switchboard installations had thus been transferred to complete Bell service prior to September 17. Because of this, and normal disconnections in the year before the final cut-over, when no new Keystone subscribers were added, the number of Keystone telephones in service dropped from 45,300, at the time Bell took title to the system, to approximately 22,400 on last September 17.

In summing up after the unification program had been completed in Pennsylvania, it was found that 5,200 service orders had been issued, resulting in a net increase of approximately 5,000 Bell lines and 12,000 telephones. Fifty-eight dial PBXs had required modification or replacement and 412 new switchboards had been installed.

Installation Problems

A TOTAL of 164 people were recruited from all over the territory of the Pennsylvania Company, and from the Keystone Division, to assist in the program, and they worked long hours of overtime to complete the tremendous installation job. They were assisted by Western Electric installers, who handled the additional central office equipment and the work on the larger dial PBXs. The regular forces in the Accounting and Directory Departments also performed a sizable job in handling the necessary changes in billing and listing records.



FOR part of its 60 miles, the old Camden & Atlantic open-wire toll line ran through swamps accessible only to men equipped with rubber boots

Because of the large number of changes in the PBX equipment, it was necessary for the Traffic Department to conduct an extensive training program for PBX operators. All operators affected were visited by Bell traffic representatives, and were given comprehensive training where new switchboards had been installed or where old boards had been modified to any large extent.

Prior to the cut-over, the large users had been provided with additional Bell lines. Some of these were so arranged at the central office that they could be put in service by inserting heat coils in the circuit. In other cases dummy plugs were placed in the trunk jacks on the PBX switchboards, which were removed by operators the day of the consolidation.

For the comparatively few individual and party-line customers who had no duplicating Bell service, it was necessary to make new Bell installations, connecting Bell lines to Keystone instruments where they were re-usable and then inserting heat coils in the Bell circuits at the time of the cut-over. Then, at the proper time, it was necessary only to close the circuits in the Bell offices, while in the Keystone offices the fuses were removed, shutting off the power.

Usable Keystone instruments were modified by providing new dial face plates and new number plates, the latter having the Bell numbers un-

ABOUT 120 TONS of copper wire were salvaged from the Camden & Atlantic line. Pictured is one of five carloads shipped to the Nassau Smelting and Refining Company

derneath with temporary Keystone plates on top, which were removed by the customers after the cut-over.

THE CLIMACTIC MOMENT came promptly at 7 A.M., with Carl R. Freehafer, vice president and general manager, Eastern Area, in charge. Stationed at the Lombard central office, he was connected by telephone with all the other offices affected, and his "let 'er go" was the signal that ended dual telephone service in Philadelphia.

At Keystone's Race central office, the fuses were pulled by J. W. Root, oldest Keystone employee, who had taken part in the inauguration of Keystone service in 1902. Now retired, Mr. Root came back for the final job.

A few minutes later the Keystone offices were virtually deserted, the switchboards and dial apparatus silent for the first time since their installation in 1921.

Although it is planned ultimately to replace all former Keystone station equipment with standard Bell System facilities, a considerable number of instruments have been modified and re-used, as well as a number of PBX systems. The net gain in usable instruments is estimated to be about 13,000, and these are being reused throughout Pennsylvania.

The PBX equipment not re-used is being sold through Western Electric, and both the central offices and their associated equipment are also being disposed of.

Due to the shortage of facilities at the present time, every effort was made to re-use all possible equipment. However, because it would be necessary to maintain repair parts stocks for equipment manufactured by several different companies and to train men in repair work, plans have been made to retire nearly all former Keystone equipment as soon as practicable after the facilities shortage ends.

New Jersey Bell's Part

MEANWHILE, the New Jersey end of the physical consolidation had been completed on the morning of March 13, 1945. The Keystone system (Eastern Telephone & Telegraph Company) operated in and around Camden, and in Cape May County in the extreme southern tip of the state; and while the New Jersey Bell Telephone Company's task was numerically smaller, it presented its own share of difficulties.

The Camden part of the job was relatively simple. Of the 1,500 Keystone telephones there, all but perhaps 300 of their users also had Bell service, and for them it was merely a matter of eliminating the Keystone service. There still was room at Bell switchboards to accommodate the remainder.

In Cape May County, however, the situation was different, and the consolidation was termed by veterans a harder job in some respects than some of the Company's major dial conversions had been. The problem was how to add a substantial number of new customers from Keystone switchboards to Bell central offices already at capacity loads and in buildings into which extra equipment, even if available, could not have been jammed with a shoehorn. Diligent consideration of all possibilities evolved a plan for interconnecting the Bell and Keystone offices at Wildwood, and also in Cape May city, so that local service between the two boards in each case could be obtained with normal operation, and toll service completed as though the two offices were tied together, through the use of a common numbering system.

Small Keystone offices at Sea Isle City and Cape May Court House were closed and their customers were transferred to Bell offices. Bell and Keystone offices at Dennisville and Woodbine, serving roughly the same areas, were continued in operation. A midget dial office at Villas was continued and later was replaced with a larger dial unit.

A unique Plant job was removal of the 40-year-old toll line linking Philadelphia and Camden with the Jersey shore area for the Keystone system. Some 1,400 miles of copper line wire, weighing about 120 tons, was removed and salvaged, 7,800 crossarms on 2,900 poles were removed, and 1,400 of the poles were taken down. Many poles were in swamp land inaccessible except to construction men on foot and wearing hip boots. Working conditions were hazardous. Much of the line flanked a heavily traveled main highway, the White Horse Pike, creating traffic risks. Many poles were defective and unsafe, and many non-standard and hazardous conditions existed. Several difficult railroad and major highway crossings were involved. All of these potential accident conditions complicated the making of some 4,000 normal "climbs" and pulling down and reeling 7,000,000 feet of wire—all of which were accomplished without a single accident.

As in the case of the Pennsylvania Company, the 66 employees of Eastern Tel. & Tel. who joined the New Jersey Bell organization received full credit for their previous service as regards benefits, pensions, and similar matters.

CONSOLIDATION of the Keystone System was the largest job of its kind ever undertaken by the Bell Telephone Company of Pennsylvania, and was completed in remarkably short time, despite the many handicaps imposed by the wartime scarcity of facilities and manpower.

Thus, after many years, the era of duplicative telephone service in Philadelphia and in adjacent New Jersey has finally come to a close, in accordance with the long accepted principle that for two telephone systems to serve the same community is wasteful, expensive, and inefficient. Another milestone has been passed in the Bell System's effort to make it possible for "anyone anywhere to pick up a telephone and talk with anyone else anywhere else. . . ."

P

PRINTED IN U. S. A.